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INTEGRATION AND FUNCTIONAL TEST PLAN

FOR THE

TROPICAL RAINFALL MEASURING MISSION

(TRMM) OBSERVATORY

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

TRMM INTEGRATION AND FUNCTIONAL TEST PLAN

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ACRONYMS

AC	Alternating Current
ACE	Attitude Control Electronics
ACS	Attitude Control Subsystem
ADP	Automated Data Processing
BC	Bus Controller
BGSE	Battery Ground Support Equipment
BOB	BreakOut Box
BRF	Band Reject Filter
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
CCTV	Closed Circuit Television
C&DH	Command & Data Handling
CEEM	Coatings and Environmental Effects Monitor
CERES	Clouds and the Earth's Radiant Energy System
CG	Center of Gravity
CMO	Configuration Management Officer
COMETS	COMmunication Engineering Test Satellite
CSS	Coarse Sun Sensor
CTV	Compatibility Test Van
DC	Direct Current
DMM	Digital Multimeter
DSN	Deep Space Network
DSS	Digital Sun Sensor
SSE	Digital Sun Sensor Electronics
CS	Environmental Control System
EGSE	Electrical Ground Support Equipment
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL	End Of Life
ESA	Earth Sensor Assembly
ESD	Electrostatic Discharge
ETU	Engineering Test Unit
EVD	Engine Valve Driver
FAM	Flight Assurance Manager
FDM	Fill and Drain Module
FDS	Flight Data System
FEDS	Front End Data System
FRB	Failure Review Board
FMEA	Failure Mode Effects Analysis
FOT	Flight Operations Team
FOV	Field Of View
GEVS-SE	General Environmental Verification Specification for STS and ELV Payloads, Subsystems, and Components
GHB	Goddard HandBook
GMI	Goddard Management Instruction
GMT	Greenwich Mean Time
GN	Ground Network
GPTU	Generic Propellant Transfer Unit
GSACE	Gimbal and Solar Array Control Electronics

GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSTDN	Ground Spaceflight Tracking and Data Network
HCC	High Capacity Centrifuge
HD	Hardware Developer
HGA	High Gain Antenna
HGAS	High Gain Antenna System
HGAD/PS	High Gain Antenna Deployment / and Pointing System
ICD	Interface Control Document
I/F	Interface
IGSE	Instrument Ground Support Equipment
I/O	Input/Output
IPSDU	Instrument Power Switching and Distribution Unit
IRU	Inertial Reference Unit
ISP	Instrument Support Platform
I&T	Integration & Test
K	Kilo (1000)
Kg	Kilogram
LAN	Local Area Network
LaRC	Langley Research Center
LBS	Lower Bus Structure
LED	Light Emitting Diode
LIS	Lightning Imaging Sensor
LISP	Lower Instrument Support Platform
MCG	Manual Command Generator
MGSE	Mechanical Ground Support Equipment
MLI	Multi-Layer Insulation
MOC	Mission Operations Center
MOI	Moment Of Inertia
MOM	Mission Operations Manager
MPMF	Mass Properties Measurement Facility
MRB	Material Review Board
MSFC	Marshall Space Flight Center
MTB	Magnetic Torquer Bar
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NHB	NASA Handbook
#2STA	Spacecraft Testing and Assembly building #2
OBC	On-board Computer
OHA	Operations Hazards Analysis
OTDR	Optical Time Domain Reflectometer
PAF	Payload Adaptor Fitting
PAR	Performance Assurance Requirements
PBIU	Power Bus Interface Unit
PC	Personal Computer
PCM	Propellent Control Module
PDF	Programmable Data Formatter
PFR	Problem/Failure Report
POCC	Payload Operations Control Center
PR	Precipitation Radar
PSE	Power Supply Electronics
PSI	Pounds Per Square Inch

PSIB	Power System Interface Box
PSK	Phased-Shift-Key
PST	Pad Service Tower
PTM	Propellent Tank Module
QA	Quality Assurance
RCS	Reaction Control System
RF	Radio Frequency
RFI	Radio Frequency Interference
RFCS	RF Communications Subsystem
RFTR	Radio Frequency Test Rack
RFTS	Radio Frequency Transfer Switch
RT	Remote Terminal
RW	Reaction Wheel
RWE	Reaction Wheel Electronics
RWM	Reaction Wheel Module
SADA	Solar Array Drive Assembly
SADDS	Solar Array Deployment and Drive System
SBRC	Santa Barbara Research Center
SCA	Spacecraft Checkout Area
SCCB	Software Configuration Control Board
SDS	Spacecraft Data Subsystem
SER	Software Enhancement Request
SES	Space Environment Simulator
SFA	Spacecraft and Fairing Assembly building
SGDDU	Spacecraft Ground Data Distribution Unit
GSE	Spacecraft Ground Support Equipment
SN	Space Network
SPR	Software Problem Report
SPRU	Standard Power Regulator Unit
SPSDU	Spacecraft Power Switching Distribution Unit
SSDIF	Spacecraft Systems Development and Integration Facility
STOL	Standard Test and Operating Language
TAM	Tri-Axial Magnetometer
TAME	Tri-Axial Magnetometer Electronics
TAR	Task Action Request
TBD	To Be Determined
TCP/IP	Transmission Control Protocol / Internet Protocol
TCS	Thermal Control Subsystem
TDRSS	Tracking and Data Relay Satellite System
TIMACC	Test Interface Monitor And Control Computer
TMI	TRMM Microwave Imager
TnSC	Tanegashima Space Center
TPOCC	Transportable Payload Operations Control Center
TRMM	Tropical Rainfall Measuring Mission
TSSM	TRMM Software Systems Manager
UISP	Upper Instrument Support Platform
UPS	Uninterruptable Power Supply
VIRS	Visible Infrared Scanner
WOA	Work Order Authorization
XTE	X-ray Timing Explorer

1.0 INTRODUCTION

This document defines the requirements, tests, facilities, equipment, and actions necessary to integrate and functionally test the Tropical Rainfall Measuring Mission (TRMM) Observatory at both the Goddard Space Flight Center (GSFC) and the Tanegashima Space Center (TnSC) in Japan. The overall responsibility for the Integration and Test (I&T) of the TRMM Observatory resides with the Observatory Manager within the TRMM Project, GSFC Code 490. The primary responsibility for the day-to-day execution resides with the I&T Manager with close support from GSFC Codes 710, 720, 730, 750, 490, 303, and the instrument representatives. At the completion of the I&T phase at the GSFC, the TRMM Observatory and all required Ground Support Equipment (GSE) will be transported to the TnSC. Once the TRMM Observatory has been checked out at the TnSC, it will be mechanically integrated into the Japanese H-II Expendable Launch Vehicle (ELV) and prepared for the subsequent launch.

Verification test plans and requirements are documented in the Verification Plan And Specification For The TRMM Spacecraft, document TRMM-750-113, to be referred to hereafter as the "TRMM Verification Plan". Policies and procedures for the administration of the TRMM I&T program are contained throughout this document.

1.1 PURPOSE

The purpose of this document is to provide sufficient information and schedule pertaining to the TRMM Observatory I&T phases such that the required elements may be successfully planned, developed, and implemented.

1.2 SCOPE

This document covers all TRMM Observatory I&T activities including integration, functional testing, environmental and verification testing, and launch site activities.

For the purpose of this document, descriptions of the TRMM subsystems, instruments, etc. are in brief form only. References are provided in the event greater detail is desired.

1.3 DEFINITION OF TERMS

For the purpose of this document the following definitions apply:

Acceptance Test: The verification process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract, or as specified in the Verification Plan.

Aliveness Test: A very brief test normally containing a turn-on procedure, and a minimum number of commands and telemetry status checks to verify the system, subsystem, or instrument is responding and seems to be operating correctly. This test is generally less than 15 minutes in length. (Aliveness Test for each subsystem and instrument can be combined to form the Observatory Aliveness Test).

Assembly: A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole, i.e., a power amplifier.

Battery Ground Support Equipment (BGSE): Refers to the GSE used to monitor, test, charge/discharge, cool, and re-condition the batteries independent of the spacecraft.

Calibration: To perform a series of tests that determine the response of the instrument to the stimulus for which it is designed to measure.

Certification Log (Cert Log): A chronological listing of events and information which provide traceability and documentation of hardware and software through all levels of assembly, integration, inspection, and testing. This includes traceability of who did what and why.

Comprehensive Performance Test: An orderly and controlled system level set of events to validate that the observatory is performing in accordance with cited specifications. It is the most detailed test. (This is also known as the Observatory Long Form Functional Test).

Consultive Committee for Space Data Systems (CCSDS): A set of recommendations for standard formatted command and telemetry data units set forth by an international committee for space data systems. It will be the command and telemetry data formatting standard implemented for the TRMM flight and ground systems.

Component: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation (i.e. a battery is a component of the power subsystem).

Electrical Ground Support Equipment (EGSE): A set of electrical test equipment designed to support the testing of the observatory. The EGSE is generally composed of the equipment which directly interfaces with the observatory through the umbilical interface. This equipment includes the umbilical console, the solar array simulator, the baseband equipment console, an analog tape recorder, a stripchart recorder, a Radio Frequency Test Rack (RFTR), and to supply backup power to most of this equipment an Uninterruptable Power Supply (UPS).

Electrostatic Discharge (ESD): The transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

End-Item: The final product. This product could either be a subassembly, an assembly, a component of a subsystem/instrument, or a complete subsystem or instrument. This product is usually a deliverable expected or required by the next level of effort.

Ground Support Equipment (GSE): A general terms which includes all equipment, both electrical and mechanical, which is used to support all aspects of the assembly, subsystem or system testing, calibration, spacecraft I&T, and launch site activities.

High-bay: The open area of building 7/10/29. These high-bay areas will be used as required as a staging area for various I&T support operations.

Instrument Ground Support Equipment (IGSE): The combination of one or more computers with related software and ancillary hardware used to interface to an instrument for instrument mode commanding, telemetry data handling and processing functions, and certain data analytical functions. Its ultimate purpose is to support all aspects of the I&T of an instrument.

Integration: The detailed step-by-step process of mechanically and/or electrically mating components or subsystems into an overall system to form a payload.

Integration Procedure: A written step-by-step document that details the steps to mechanically or electrically mate two or more elements, components, subsystems, etc.

I&T Team: All personnel involved with TRMM I&T activities. This includes subsystem engineers, instrument engineers, test conductors, technicians, test support personnel, etc.

Long Form Functional Test: An orderly and controlled system level set of events to validate that a subsystem/instrument is performing in accordance with cited specifications. It is the most detailed test. (Long Form Functional Test for each subsystem and instrument can be combined to form the Observatory Long Form Functional Test also known as the Comprehensive Performance Test).

Mechanical Ground Support Equipment (MGSE): A set of mechanical fixtures, both special purpose and generic, designed to support the mechanical requirements during testing of the observatory, an instrument, or subsystem. These are equipment such as holding fixtures, specialized calibration fixtures, lifting slings, etc.

Observatory: The Observatory consists of the spacecraft combined with the integrated instruments.

Operations Room: Referred to as the TRMM I&T Operations Room, will accommodate the SGSE and IGSE computer systems, spacecraft and instrument test conductors, and other personnel required for observatory integration, functional testing, and other required activities. This will be the "home base" area from where all spacecraft and instrument operations and testing will be controlled during all observatory I&T phases.

Problem/Failure Report (PFR): A form used for recording information pertaining to a system, subsystem, component, assembly, or subassembly failure or malfunction (see Figure 4.9).

Short Form Functional Test: An orderly and controlled system level set of events to validate that a subsystem/instrument is performing in accordance with cited specifications. It is an abbreviated version of the Long Form Functional Test. (Short Form Functional Test for each subsystem and instrument can be combined to form the Observatory Short Form Functional Test).

Space Environment Simulator (SES): A 27 foot wide by 40 feet tall usable test volume thermal vacuum chamber which will be used for the TRMM thermal vacuum / thermal balance flight qualification test. The SES is located in building 10.

Spacecraft: The Spacecraft consists of the integrated combination of the mechanical structure and electrical components, minus the instruments.

Spacecraft Ground Support Equipment (SGSE): Also referred to as the spacecraft I&T computer system, consisting primarly of workstations from where the spacecraft test conductors will operate and control the observatory. Also includes mass data storage units for archiving, hardware for command and telemetry interfaces, and an ethernet network to the IGSEs.

SGSE Simulator: The portion of the spacecraft interface simulator that simulates the SGSE (see spacecraft interface simulator).

Spacecraft Interface Simulator: A "standard" spacecraft interface simulator will provide selected spacecraft power, and all command and telemetry interfaces presented to the instrument by the spacecraft. Additionally, it will contain the IGSE to SGSE interface that will be required for I&T at the GSFC. Each instrument group will be provided a spacecraft interface simulator during selected periods of instrument development.

Standard Test and Operations Language (STOL): An interactive software package containing many sets of unique software packages which provide the user a high level means of creating databases, page displays, etc. On-line test capability from a workstation is provided for sending commands, telemetry presentation and verification, and execution of automated computer based test procedures.

STOL Test Procedure: A unique file containing a written set of STOL instructions which when implemented will perform various functions required to operate and test a subsystem or system. STOL Test Procedures reside in the SGSE. STOL test procedures are executed and controlled via keyboard instructions. They may contain any of the following: commands mnemonics, telemetry verification checks, page display prints, limit definitions, etc.

Subassembly: A functional subdivision of an assembly, i.e., a printed circuit board.

Subsystem: A functional subdivision of a payload consisting of two or more components. Examples are electrical, thermal, and Radio Frequency (RF) communications subsystems.

Task Action Request (TAR): The request originated by a member of the TRMM I&T team, routed through the TRMM Verification Manager requesting that a specific task, test, or support service be provided by the GSFC Code 754 and/or their in-house contractors.

Work Order Authorization (WOA): A written set of step-by-step instructions defining a specific task to be performed. These are numbered, cataloged, tracked, and maintained by the I&T Coordinator.

1.4 TRMM I&T TEAM ORGANIZATION

The TRMM I&T Team is comprised of engineers and technicians from the Engineering Directorate (GSFC Code 700) with support services from various contractor organizations. In addition, instrument personnel, such as instrument managers, instrument engineers, and instrument I&T support personnel will be part of the TRMM I&T team along with flight assurance personnel from GSFC Code 300. The TRMM Observatory Manager (GSFC Code 490) has overall responsibility for all TRMM Observatory operations. The TRMM I&T Manager (GSFC Code 733) is in charge of the daily TRMM I&T and pre-launch activities. The TRMM I&T Organization chart is shown in Figure 1-1.

1.4.1 ORGANIZATIONAL I&T RESPONSIBILITIES

The following GSFC organizations are responsible for the delivery, integration, and test support of the various observatory subsystems and instruments, or for other I&T support items.

TABLE 1-1 - ORGANIZATIONAL I&T RESPONSIBILITIES

I&T Responsibility	ORGANIZATION
TRMM Observatory Manager	GSFC Code 490
TRMM Systems/Liaison Manager	GSFC Code 490
TRMM Instrument Systems Manager	GSFC Code 490
TRMM I&T Manager	GSFC Code 733
TRMM I&T Assistant Managers	GSFC Code 733
TRMM I&T Floor Directors	GSFC Code 733
TRMM I&T Coordinator / I&T CMO	GSFC Code 733
TRMM Senior Systems Engineer	GSFC Code 704
TRMM Software Systems Manager	GSFC Code 490
TRMM I&T Coordinator	GSFC Code 733
TRMM Verification Manager	GSFC Code 750
TRMM Flight Assurance Manager	GSFC Code 303
TRMM Safety Manager	GSFC Code 302
TRMM Contamination Control Manager	GSFC Code 724
TRMM Launch Vehicle/Site I/F Manager	GSFC Code 490
TRMM Mission Operations Manager	GSFC Code 501
TRMM Flight Software Manager	GSFC Code 735
TRMM Configuration Management Officer	GSFC Code 490
TRMM Environmental Test Directors	GSFC Code 490*
Facility Environmental Test Directors	GSFC Code 754*
Spacecraft Test Conductors	GSFC Code 733
I&T Electrical Technicians	GSFC Code 733
I&T Mechanical Technicians	GSFC Code 754
Electrical Ground Support Equipment	GSFC Code 733
Spacecraft Ground Support Equipment	GSFC Code 733
Mechanical Ground Support Equipment	GSFC Code 722
Spacecraft Electrical/Optical Harness	GSFC Code 733
Attitude Control Subsystem	GSFC Code 712
Deployables Subsystem	GSFC Code 722
Electrical Subsystem	GSFC Code 733
HGAS Subsystem	GSFC Code 723
Power Subsystem	GSFC Code 734
Reaction Control Subsystem	GSFC Code 713
RF Communications Subsystem	GSFC Code 737
Spacecraft Data Subsystem	GSFC Code 735
Structural Subsystem	GSFC Code 722
Thermal Subsystem	GSFC Code 724
Contamination Control Subsystem	GSFC Code 724
Contamination Control	GSFC Code 724
CERES Instrument And IGSE	GSFC Code 421
LIS Instrument And IGSE	GSFC Code 490
PR Instrument And IGSE	GSFC Code 490
TMI Instrument And IGSE	GSFC Code 490
VIRS Instrument And IGSE	GSFC Code 490

* - The TRMM environmental test directors are either GSFC Code 490 personnel or personnel appointed and approved by the TRMM Project. The facility environmental test directors are either GSFC Code 754 personnel or one of their in house contractors. (See paragraph 1.4.1.1 and 10.1 for more information about environmental test directors).

1.4.1.1 KEY I&T INDIVIDUALS

This section will outline the major (but not all) I&T responsibilities for various key I&T individuals.

- TRMM Observatory Manager -

The TRMM Observatory Manager is the GSFC Code 490 project management representative responsible for all aspects of the TRMM Observatory including all I&T activities. He has the primary responsibility for the overall I&T planning and he approves all observatory integration, functional, and environmental test plans and procedures.

- TRMM I&T Manager -

The TRMM I&T Manager is responsible for the detailed planning, organization, implementation, and control of all observatory I&T activities. He directs the I&T team and he approves all I&T test procedures. The TRMM I&T Manager reports to the Observatory Manager.

- TRMM I&T Assistant Managers -

TRMM I&T Management (other than the TRMM I&T Manager) will assist the TRMM I&T Manager as directed and required. They will be responsible for overseeing daily I&T activities when directed by the I&T Manager or when the I&T Manager is not available. They will report to the I&T Manager.

- TRMM I&T Floor Directors -

The TRMM I&T Floor Directors will be assigned by the TRMM I&T Manager. They will be the government manager on the floor directing and overseeing the daily I&T activities. They will resolve any conflicts they may arise and will have the authority to stop the activity until a resolution is made. The TRMM I&T Floor directors will primary be I&T Assistant Managers, however the environmental test directors will also serve in this capacity during their respective test.

- TRMM Senior Systems Engineers -

The TRMM Senior Systems Engineers are technical authorities for the TRMM Observatory. They provides technical insight and oversight for various observatory level system issues as needed throughout the TRMM Program, including the I&T phase. The Senior Systems Engineers are responsible for assuring that all spacecraft requirements are verified according to the verification plan.

- TRMM I&T Coordinator / I&T CMO -

Both the TRMM I&T Coordinator and the I&T CMO acts as an assistant to the TRMM I&T Manager. In addition, the TRMM I&T Coordinator and I&T CMO will support each other as required. Primarly, the I&T Coordinator will be responsible to coordinate activities between the TRMM I&T Team, the Verification Manager, the Environmental Test Engineering Branch (GSFC Code 754), and in-house support contractors in the implementation of test site needs; assists in the preparation of TARs; distributes integration test procedures to the I&T Team; tracks test equipment and schedules calibration and repairs; arranges for photographs and video taping; and coordinates as needed launch site facility requirements with launch site personnel. The I&T CMO acts as the focal point for the correct preparation, routing, distribution, tracking, and maintenance of completed "as run" WOAs; alerts all parties responsible for procedure deliverables, and tracks procedure readiness; and assures that an original and "as run" copy of all integration procedures are filed.

- TRMM Verification Manager -

The TRMM Verification Manager supports the I&T Manager as the responsible individual for planning and coordinating the facility support required for each I&T activity. This includes assuring that a facility environmental test director is assigned for each environmental test activity, generating and monitoring TARs, and arranging pre and post environmental reviews including the supporting test requirements and reports.

- Environmental Test Directors -

Environmental Test Directors fall into two distinct groups: (1) GSFC Code 490 personnel or personnel appointed and approved by the TRMM Project who are responsible for "directing" the various environmental tests from the project's perspective, and (2) GSFC Code 754 personnel or one of their in house contractors who are responsible for the various environmental test facilities.

- TRMM Flight Assurance Manager -

The TRMM Flight Assurance Manager (FAM) will support the I&T Manager during I&T and reports to the TRMM Project Manager. The Flight Assurance Manager and his team will oversee, monitor, and inspect all work performed on the observatory during I&T. They will review procedures, verify the correct implementation and execution of procedures, verify that all precautions are followed, and verify that all deviations and problem reports are documented and dispositioned.

- TRMM Safety Manager -

Throughout all aspects of the TRMM I&T program, the TRMM Safety Manager is responsible for providing an assessment of the hazards associated with the TRMM Observatory and to identify safety design and procedural controls to be imposed on the system elements to preclude or minimize the probability of an occurrence or a mishap which could cause injury to personnel and/or damage to equipment. The TRMM Safety Manager reports to the Flight Assurance Manager, the Observatory Manager, and the I&T Manager.

- TRMM Contamination Control Manager -

The TRMM Contamination Control Manager reports to the I&T Manager, and is responsible for setting the requirements necessary to achieve the TRMM contamination budget. This individual shall provide the TRMM Contamination Control Plan and approved implementation plans, and is responsible for the planning and direction required to assure proper contamination control on a daily basis.

- TRMM Launch Vehicle / Launch Site Interface Manager -

The Launch Vehicle / Launch Site Interface Manager shall be responsible for defining launch vehicle / launch site interfaces, working related issues, verifying requirements and capabilities, and planning launch site activities to ensure a smooth operation once the observatory arrives at the launch site and to ensure that the observatory / launch vehicle interface is compatible. The Launch Vehicle / Launch Site Interface Manager reports to the TRMM Observatory Manager and works closely with the TRMM I&T Manager.

- TRMM Software Systems Manager -

The TRMM Software Systems Manager (TSSM) is responsible for the oversight of all TRMM software elements. He is responsible for insuring that all TRMM flight software requirements are verified, particularly requirements that can only be verified on the TRMM Observatory during I&T. The TSSM also serves as chairman of the TRMM Project Software Configuration Control Board (SCCB), which will coordinate all required updates to the TRMM flight software, GSE software, and data base elements during I&T. The TSSM also coordinates project software issues with GSFC Code 500 (as needed), including the release of the project data base. The TSSM reports to the TRMM Deputy Project Manager.

- TRMM Spacecraft Test Conductors -

The TRMM Spacecraft Test Conductors are ultimately responsible for being in charge and orchestrating spacecraft and observatory powered up operations. This can range from electrical integration test to observatory long form functional test. The Spacecraft Test Conductors shall have interface, and working or operational knowledge of all EGSE systems, spacecraft subsystems, and preferrably operational knowledge of the instruments. They shall have knowledge of the spacecraft to instrument interfaces, and higher level knowledge of instrument commands and telemetry. In preparation for the powered up operations the Spacecraft Test Conductors shall develop and maintain command and telemetry databases, page displays, support the subsystem/instrument engineers in the development of integration procedures, develop STOL automated test procedures, and other as required user generated "software".

- TRMM Mechanical Technicians -

The TRMM Mechanical Technicians will support and report to the Structural Subsystem Lead Engineer and the I&T Manager. They will be responsible for mechanical operations performed on the TRMM Observatory during I&T, for example performing the mechanical integration of a component onto the observatory.

- TRMM Electrical Technicians -

The TRMM Electrical Technicians will support and report to the Spacecraft Test Conductors, the Electrical Subsystem Lead Engineer, and the I&T Manager. They will be responsible for performing all connector mate/demate operations, electrical probing and measurements, harness work, building special jumpers and cables, and operating the EGSE.

- TRMM Configuration Management Officer -

The TRMM Configuration Management Officer (CMO) will maintain the master database of approved documents, schedules, schematics, integration procedures, test reports, copies of completed WOAs (as requested), and configuration logs. Control numbers for documents, drawings, and schematics are assigned by the TRMM CMO. The TRMM CMO will maintain all historical records of the TRMM I&T program. The TRMM CMO reports to the TRMM Project Manager.

- TRMM Subsystem Lead Engineers -

The TRMM Subsystem Lead Engineers are responsible for supporting their respective subsystems throughout all phases of I&T including component receiving and inspection, acceptance testing, spacecraft integration, performance testing, environmental testing, launch site operations, and in-orbit checkout. In addition, they are to provide the spacecraft test conductors with sufficient information for database generation, test procedure generation, and operational knowledge for their subsystem and any other required information for I&T purposes. Also, the Subsystem Lead Engineers are responsible for providing integration procedures for each component of their subsystem. The Subsystem Lead Engineers primarily report to the Observatory Manager, but shall defer to the I&T Manager as the Observatory Manager's representative for daily I&T activities.

- TRMM Instrument Managers -

The TRMM Instrument Managers are the TRMM Project's contacts for resolving the technical and programmatic issues of the TRMM Spacecraft to instrument interfaces. They, or an appointed instrument representative, will coordinate instrument operations for their respective instrument with the I&T Manager throughout all phases of I&T including instrument receiving and inspection, acceptance testing, spacecraft integration, performance testing, environmental testing, launch site operations, and in-orbit checkout. In addition, they are to provide the spacecraft test conductors with sufficient information for database generation, test procedure generation, and operational knowledge for their instrument and any other required information for I&T purposes. Also, the Instrument Managers are responsible for providing integration procedures for each instrument component. The Instrument Managers primarily report to the Instrument Systems Manager, but shall defer to the I&T Manager as the Observatory Manager's representative for daily I&T activities.

- Instrument Test Conductors -

Each TRMM Instrument team will supply a minimum of one test conductor who is thoroughly familiar with the operational aspects of the instrument and associated IGSE. These personnel will be the operations focal point for powered up conditions, which include the issuance of commands, verification of data, and the prime interface to the spacecraft test conductors and other instrument test conductors, for their particular instrument. Several instrument test conductors for each instrument will be required for periods of extended operation during environmental test activities.

1.5 APPLICABLE DOCUMENTS

The following documents are applicable to the integration, functional testing, handling, and calibration of the TRMM Observatory. In the event there are conflicts between this document and the source document, the source document shall prevail. The following documents contain more detailed requirements, information, and specifications relevant to the TRMM Project.

(All documents listed in this section contain information applicable and useful for I&T purposes. However, this list is not complete. All documents listed in this section which are denoted by an asterisk "*" are documents that are specifically referenced throughout this plan.)

1.5.1 TRMM SPECIFICATIONS

TRMM-490-001	TRMM Mission Specification
TRMM-490-002	TRMM System Specification - Space Segment
TRMM-490-026	TRMM Performance Specification For The TRMM Microwave Imager Instrument
TRMM-490-027	TRMM Performance Specification For The Visible And Infrared Scanner Instrument
TRMM-713-031	TRMM Reaction Control Subsystem Specification
*TRMM-733-043	TRMM Electrical Subsystem Specification
TRMM-727-044	TRMM Communication Subsystem Specification
TRMM-733-045	TRMM Electrical Ground Support Equipment Specification
TRMM-712-046	TRMM Attitude Control Subsystem Specification
TRMM-735-047	TRMM Command & Data Handling Subsystem Specification
TRMM-731-048	TRMM Deployables Subsystem Specification
TRMM-731-049	TRMM Structural Subsystem Specification
TRMM-712-050	TRMM Attitude Control Subsystem Software Specification
TRMM-711-055	TRMM Power Subsystem Specification
TRMM-732-071	TRMM Thermal Subsystem Specification
TRMM-735-125	TRMM Flight Data System Software Requirements Specification
TRMM-723-134	TRMM High Gain Antenna System Specification
*TRMM-TBD-TBD	TRMM Spacecraft - Launch Operations Interface Control Specification (TBD)

1.5.2 TRMM INTERFACE CONTROL DOCUMENTS

TRMM-727-018	TRMM Communications Subsystem Interface Control Document
TRMM-731-019	TRMM Deployable Subsystem Interface Control Document
TRMM-731-020	TRMM Structural Subsystem Interface Control Document
TRMM-490-021	TRMM Spacecraft To Clouds And The Earth's Radiant Energy System Instrument Interface Control Document
TRMM-490-022	TRMM Spacecraft To Lightning Imaging Sensor Instrument Interface Control Document
TRMM-490-023	TRMM Spacecraft To TRMM Microwave Imager Instrument Interface Control Document
TRMM-490-024	TRMM Spacecraft To Visible Infrared Scanner Instrument Interface Control Document
TRMM-490-025	TRMM Spacecraft To Precipitation Radar Instrument Interface Control Document
TRMM-713-032	TRMM Reaction Control Subsystem Interface Control Document
TRMM-712-052	TRMM Attitude Control Subsystem Interface Control Document
TRMM-735-053	TRMM Command & Data Handling Subsystem Interface Control Document
TRMM-711-057	TRMM Power Subsystem Interface Control Document
TRMM-733-059	TRMM Electrical Subsystem Interface Control Document
TRMM-732-070	TRMM Thermal Subsystem Interface Control Document
*TRMM-733-104	TRMM IGSE To SGSE Interface Control Document

1.5.3 TRMM PLANS AND PROCEDURES

TRMM-490-009	TRMM Implementation Plan (Volume No. 1 - Pre-Launch/Development Activities)
*TRMM-490-009	TRMM Implementation Plan (Volume No. 2 - Launch Operations)
*TRMM-750-113	TRMM Verification Plan and Specification For The TRMM Spacecraft
TRMM-303-014	TRMM Safety Plan
*TRMM-303-015	TRMM Assurance Implementation Plan
*TRMM-732-016	TRMM Contamination Control Plan
*TRMM-733-054	TRMM Electrostatic Discharge Control Implementation Plan
TRMM-724-108	TRMM Cleaning And Cleanliness Verification Procedure
*TRMM-724-109	TRMM Clean Area And Personnel Operations Procedure
*TRMM-733-206	TRMM Environmental Test Program Plan Overview
*TRMM-TBD-TBD	TRMM Pyrotechnics Handling Plan (TBD)
*TRMM-722-TBD	TRMM Observatory Handling Plan And Procedures (TBD)
*TRMM-TBD-TBD	TRMM Shipping Implementation Plan (TBD)
*TRMM-TBD-TBD	TRMM Launch Site Plan
*TRMM-724-TBD	TRMM Launch Site Contamination Control Plan
*TRMM-722-AP-001	TRMM Mechanical Integration And Testing Flow Plan

1.5.4 OTHER DOCUMENTS

*TRMM-303-006	TRMM Performance Assurance Requirements
*TRMM-733-095	TRMM Integration & Test Ground Computer System Requirements
*TRMM-490-165	TRMM Project Schedule Baseline Document
*TRMM-735-127	TRMM Flight Data Subsystem Software User's Guide

*TRMM-490-131 TRMM Phase 1 Safety Data Package
*TRMM-490-132 TRMM Phase 2 Safety Data Package
*TRMM-490-133 TRMM Phase 3 Safety Data Package
*TRMM-733-105 TRMM Spacecraft Simulator Description Document
*TRMM-733-120 TRMM Spacecraft Simulator Requirements Document
P-311-540 EEE Parts and Devices Discrepancies
*P-303-820 The GSFC Certification Log
P-303-835 Contamination Control Monitoring
*P-303-840 ESD Control Plan
*P-303-841 ESD Training Requirements
*P-303-842 ESD Facilities Requirements
*P-303-843 ESD Handling Requirements
*P-303-844 Audit Of ESD
P-303-845 Problem Record Item
P-303-846 Material Review Board
P-303-849 Failure Reporting
*P-303-857 Lifting Of Space Flight Hardware
*733 SGSE User's Guide
X-750-93-004 Guidelines for Preparing Environmental Test Procedures
GMI-5310.4 Management and Control of Space Flight Hardware At GSFC
*GMI/GHB-5330.8 Metrology And Calibration
*NHB-5300.4(3A-2) Requirements For Soldered Electrical Connections
*NHB-5300.4(3G) Requirements For Interconnecting Cables, Harnesses, And Wiring
*NHB-5300.4(3H) Requirements For Crimping And Wire Wrap
General Environmental Verification Specification For STS And ELV Payloads, Subsystems, And Components (GEVS-SE)

1.5.5 TRMM OBSERVATORY HARNESS DRAWINGS

The TRMM Observatory harness drawings will be generated and maintained by GSFC Code 733 using a Personal Computer (PC) based system. They will be available as connector to connector diagrams and in wirelist form. Several forms of sorted information, e.g., by number or function, will be available. The harness drawings will be placed and maintained under configuration control by the I&T CMO.

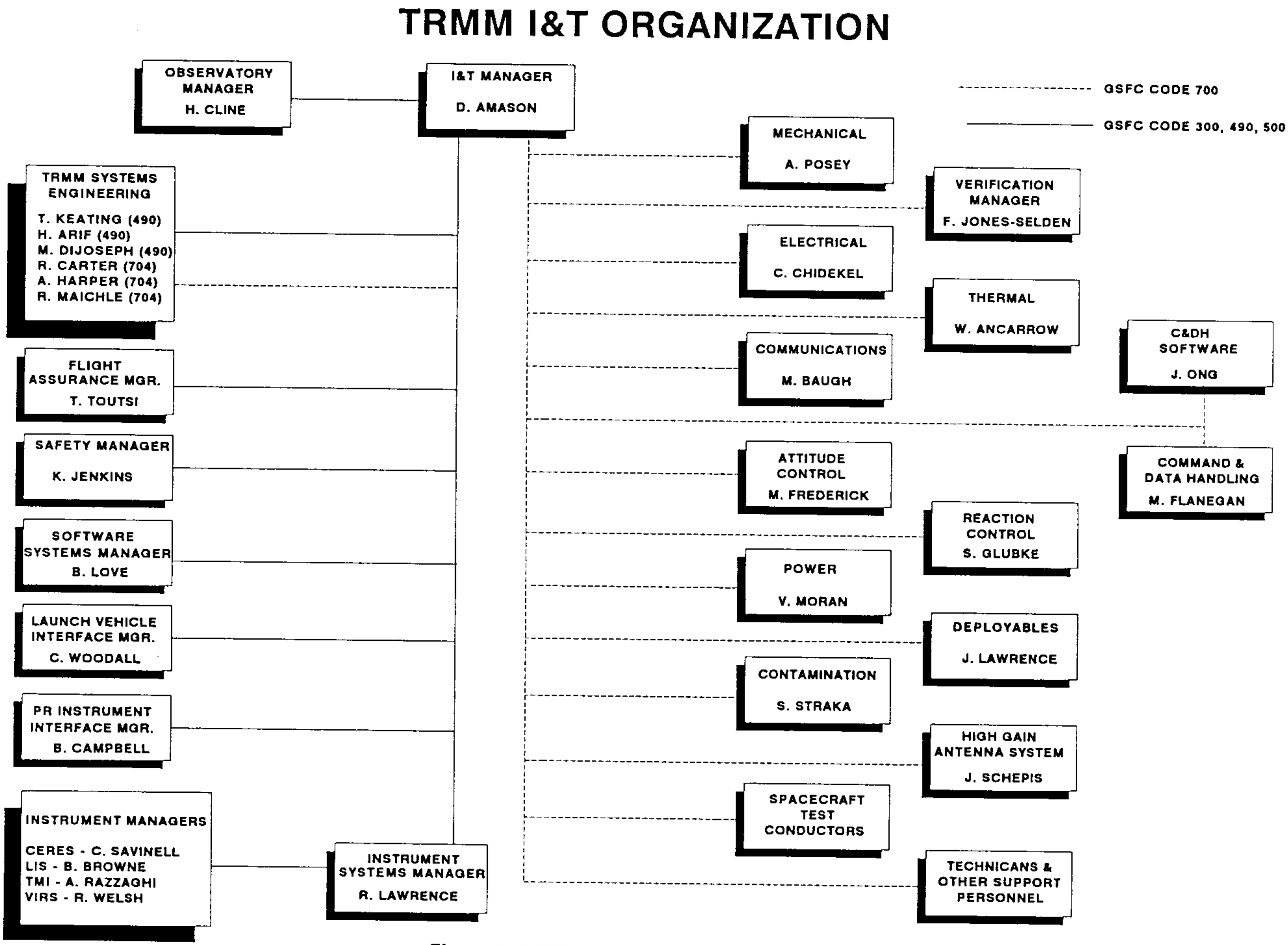


Figure 1-1 TRMM I&T ORGANIZATION CHART

2.0 TRMM DESCRIPTION

The Tropical Rainfall Measuring Mission (TRMM) is a joint mission between the National Aeronautics and Space Administration (NASA) of the United States of America and the National Space Development Agency (NASDA) of Japan. The primary scientific objectives of the TRMM mission are to measure and study the tropical and subtropical rainfall rates.

The TRMM Observatory will be launched by the Japanese H-II expendable launch vehicle from Tanegashima, Japan. The TRMM mission life is planned for 3 years at the orbital altitude and inclination of 350 kilometers and 35 degrees, respectively.

The flight configuration of the TRMM Observatory is shown in Figure 2-1.

2.1 TRMM OBSERVATORY SUBSYSTEMS

The TRMM Observatory consists of the following major subsystems:

- Structural
- Power
- Electrical Distribution
- Thermal Control
- RF Communications
- Attitude Control
- Reaction Control
- Deployables / HGAS
- Command and Data Handling
- Contamination Experiment and Molecular Adsorber

2.1.1 STRUCTURAL SUBSYSTEM

The TRMM Structural Subsystem will provide the platform for all mission-unique equipment and instruments. The design of the mechanical structure is driven by a combination of the following constraints; the Field-Of-View (FOV) requirements for the instruments, the solar array and antenna appendages, attitude, the interface to the Precipitation Radar instrument, to fit within the envelope of the H-II launch vehicle, H-II launch loads, and the overall weight constraint of 3620 Kilograms (Kg). The Structural Subsystem is comprised of the following components:

- Lower Bus Structure (LBS)
- Propellant Tank Module (PTM)
- Reaction Wheel Module (RWM)
- Lower Instrument Support Platform (LISP)
- Instrument Support Platform (ISP)
- Upper Instrument Support Platform (UISP)
- Kinematic Mounts

2.1.2 POWER SUBSYSTEM

The TRMM Power Subsystem will provide power for all spacecraft and instrument loads from an unregulated bus. The Power Subsystem consist of solar arrays sized to provide the power required through the lifetime of the mission. The Power Subsystem also consists of power switching protection, power storage, power distribution, and mission-unique control electronics. The Power Subsystem is comprised of the following components:

- Standard Power Regulator Unit (SPRU)
- Power Bus Interface Unit (PBIU)
- Power Signal Interface Box (PSIB)
- 2 50 Ampere-hour Batteries
- 2 Solar Array Wings (4 panels total, 2 per wing)

2.1.3 ELECTRICAL SUBSYSTEM

The TRMM Electrical Subsystem will switch and distribute power throughout the observatory and will control the pyrotechnics required for deployment of the High Gain Antenna (HGA), two solar array wings, the TRMM Microwave Imager (TMI) Instrument, and the opening of the Reaction Control Subsystem (RCS) pyrotechnic valve. Also, the Electrical Subsystem will provide an array of miscellaneous command and telemetry Input/Output (I/O) functions including thermistor monitoring for the spacecraft subsystems and instruments. The Electrical Subsystem is comprised of the following components:

- Spacecraft Power Switching and Distribution Unit (SPSDU)
- Instrument Power Switching and Distribution Unit (IPSDU)
- Electrical Wiring Harness

2.1.4 THERMAL CONTROL SUBSYSTEM

The TRMM Thermal Control Subsystem (TCS) will be designed to provide a controlled thermal environment for the successful operation of the instruments, electronic boxes, and other spacecraft components during ground, launch, ascent, attitude acquisition, and normal mission operations. The TRMM TCS is comprised of the following components:

- Heaters
- Temperature Sensors
- Thermostats
- Multi-Layer Insulation (MLI) Blankets
- Louvers
- Radiator Panels
- 6 Electronic Temperature Controller Units
- 4 Heat Pipes
- Thermal Coatings

2.1.5 RF COMMUNICATIONS SUBSYSTEM

The TRMM RF Communications Subsystem (RFCS) will provide the RF interface between the observatory and the ground segment via the Tracking and Data Relay Satellite System (TDRSS), and will provide the forward and return links for observatory command, telemetry, and tracking operations. The RFCS will also be compatible with the Ground Spaceflight Tracking and Data Network (GSTDN) and the Deep Space Network (DSN). The TRMM RFCS is comprised of the following components:

- 2 NASA Second Generation TDRSS Transponders
- 4 RF Transfer Switches (RFTS)
- 2 RF Power Amplifiers
- 2 Band Reject Filters (BRF)
- 2 Diplexers
- 2 RF Terminators
- RF Combiner
- High Gain Antenna (HGA)
- 2 Omnidirectional Antennas
- RF Cables

2.1.6 ATTITUDE CONTROL SUBSYSTEM

The TRMM Attitude Control Subsystem (ACS) will provide attitude determination and control capability during all operational phases of the mission including launch vehicle separation, earth acquisition and stabilization, yaw and orbit adjustment maneuvers, and normal earth pointing. During normal operations, the ACS will provide 3-axis stabilization relative to the orbit normal and a nadir reference as defined by the horizon bisector which is determined by the onboard Earth Sensor Assembly (ESA). The TRMM ACS is comprised of the following components:

- Attitude Control Electronics (ACE)
- 4 Reaction Wheel Electronics (RWE)
- 4 Reaction Wheels (RW)
- 2 Digital Sun Sensor Electronics (DSSE)
- 4 Digital Sun Sensors (DSS)
- 8 Coarse Sun Sensors (CSS)
- 2 Tri-Axial Magnetometers Electronics (TAME)
- 2 Tri-Axial Magnetometers (TAM)
- Inertial Reference Unit (IRU)
- 3 Magnetic Torquer Bars (MTB)
- Earth Sensor Assembly (ESA)
- Engine Valve Driver (EVD)

2.1.7 REACTION CONTROL SUBSYSTEM

The TRMM Reaction Control Subsystem (RCS) will provide the propellant supply and thrusters to control, maneuver, and maintain the orbit velocity and altitude of the TRMM Observatory during the 3-year operational lifetime. Also at End Of Life (EOL), the RCS will provide sufficient propellant for a controlled and safe ocean disposal of the TRMM Observatory. The TRMM RCS is comprised of the following components:

- Propellent Control Module (PCM)
- 2 Propellent Tanks
- Fill and Drain Module (FDM)
- Pressurant Tank
- Pyrotechnic Valve
- Pressure Regulator
- Propellant/Pressurant Lines
- Thrusters (12 Modules)
- Hydrazine
- Pressurant (Gaseous Nitrogen)

2.1.8 DEPLOYABLES/HGAS SUBSYSTEMS

The TRMM Deployables/High Gain Antenna System (HGAS) Subsystems will provide the pyrotechnics, mechanisms and control electronics to deploy and control the solar arrays and HGA. The Deployables Subsystem provides the rotary actuators for each of the two solar array wings to maximize the solar flux on the arrays. In addition, the HGAS Subsystem not only controls the position of the solar arrays but the position of the steerable HGA so that the link margins between the observatory and TDRSS is maximized. The Deployables/HGAS Subsystems consist of the following components:

- 2 Solar Array Deployment and Drive Systems (SADDS) (includes Pyrotechnics and Potentiometers)
- High Gain Antenna Deployment / and Pointing System (HGAD/PS) (includes Pyrotechnics and Potentiometers)
- Gimbal and Solar Array Control Electronics (GSACE)

2.1.9 COMMAND AND DATA HANDLING SUBSYSTEM

The TRMM Command and Data Handling (C&DH) Subsystem is commonly refered to as the Spacecraft Data Subsystem (SDS). For I&T purposes the C&DH Subsystem will be refered to as the SDS. The TRMM SDS includes the hardware components of the observatory which provide timing and control, command execution and storage, telemetry sampling and storage, and telemetry coding. In addition the SDS On-Board Computer (OBC) performs functions such as stored command processing, attitude control algorithm processing, absolute time computation orbit propagation, and observatory status and health and safety monitoring. The flight software resident on the SDS is commonly refered to as the Flight Data System (FDS) which control the SDS operation. The SDS is comprised of the following components:

- 2 Spacecraft Data Subsystem Electronic Units
- 2 Frequency Standards
- 6 Star Couplers
- 6 Optical Fiber Harness Sets

2.1.10 CONTAMINATION EXPERIMENT AND MOLECULAR ADSORBER

The TRMM Observatory will contain a contamination experiment called the Coatings and Environmental Effects Monitor (CEEM). The purpose of this experiment is to gather atomic oxygen material response and contamination phenomenology data required in the desing of low earth orbit and long duration spacecraft. Also, the TRMM Observatory will contain a molecular contamination adsorber vent. The purpose of this vent is to adsorb molecular contaminates released from the TRMM Observatory thus minimizing the deposition of molecular contaminates on sensitive surfaces.

The CEEM and the molecular contamination adsorber vent are not considered as TRMM Observatory subsystems. However, for I&T purposes, and the purpose of this document they will be treated as subsystems.

2.2 TRMM INSTRUMENT COMPLEMENT

The instrument complement for the TRMM Observatory consists of the following:

- Precipitation Radar (PR)
- TRMM Microwave Imager (TMI)
- Visible Infrared Scanner (VIRS)
- Lightning Imaging Sensor (LIS)
- Clouds and the Earth's Radiant Energy System (CERES)

2.2.1 PRECIPITATION RADAR

The Precipitation Radar (PR) instrument is the most innovative instrument being flown on the TRMM Observatory. It is the first quantitative PR instrument to be flown in space. The PR instrument will provide measurements of rainfall rates over both land and sea. When properly combined with the passive microwave measurements, the PR instrument data will be instrumental in obtaining the height profile of the precipitation content. From this data, the profile of latent heat release can be estimated.

The PR instrument, the PR IGSE, and any other special required GSE is being designed, developed, provided, and delivered by NASDA.

2.2.2 TRMM MICROWAVE IMAGER

The TRMM Microwave Imager (TMI) is a passive nine channel dual-polarized microwave radiometer. The TMI instrument will provide data related to rainfall rates over both land and sea. However, the data over land is less reliable where non-homogeneous surface emissions make interpretation difficult. The TMI instrument will be similar to instruments flown aboard other satellites. The data from the TMI instrument will be used and supported by the data from the PR instrument.

The TMI instrument, the TMI IGSE, and any other special required GSE is being designed, developed, and delivered by the Hughes Space and Communications Company.

2.2.3 VISIBLE INFRARED SCANNER

The Visible Infrared Scanner (VIRS) instrument is similar to other instruments flown aboard other meteorological satellites. The VIRS instrument for TRMM will be specifically designed for TRMM orbit and TRMM scientific requirements. The data from the VIRS instrument will be used in conjunction with data from the CERES instrument to determine cloud radiation. Correlation of the microwave, visible and infrared data is expected to provide the means whereby visible and infrared data alone can be more conclusively analyzed for precipitation contents. The VIRS instrument will enable a "calibration" of precipitation indices empirically derived for rain estimation from visible and infrared instruments on geosynchronous and low-earth orbit satellites.

The VIRS instrument will be a cross-track scanning radiometer which measures scene radiance in five spectral bands operating in the visable through the infrared spectral regions.

The VIRS instrument, the VIRS IGSE, and any other special required GSE is being designed, developed, and delivered by the Hughes Santa Barbara Research Center (SBRC). The VIRS instrument is comprised of the following components:

- VIRS Electronics Unit
- VIRS Scanner Unit
- VIRS Electronics - Scanner Interface Cables

2.2.4 LIGHTNING IMAGING SENSOR

The Lightning Imaging Sensor (LIS) instrument is an optical staring telescope and filter imaging system which will acquire and investigate the distribution and variability of both cloud-to-ground and intracloud lightning over the Earth. The data from the LIS instrument can be correlated to the global rates, amounts, and distribution of precipitation, and to the release and transport of latent heat. The LIS instrument is an updated version of a similar instrument being flown aboard another NASA observatory.

The LIS instrument, the LIS IGSE, and any other special required GSE is being designed, developed, and delivered by the Marshall Space Flight Center (MSFC). The LIS instrument is comprised of the following components:

- LIS Instrument Sensor Assembly
- LIS Electronics Assembly
- LIS Instrument Sensor Assembly - Electronics Assembly Interface Cables

2.2.5 CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM

The Clouds and the Earth's Radiant Energy System (CERES) instrument is a crosstrack scanning radiometer with the capability of operating in either an elevation scan mode or a biaxial scan mode. For the CERES instrument aboard the TRMM Observatory, the elevation scan will be the primary mode of operation. The biaxial scan mode capability may be selected as required. The CERES instrument provides data on the Earth's radiation budget and atmospheric radiation from the top of the atmosphere to the surface of the Earth. The CERES instrument is an improved and modified version of an instrument previously flown aboard another satellite, and is similar to other instruments presently being developed for other programs. The CERES instrument will provide three spectral changes over the range of 0.3 to 50 micrometers.

The CERES instrument, the CERES IGSE, and any other special required GSE is being designed and developed by TRW, and delivered by the Langley Research Center (LaRC).

2.3 SUBSYSTEM/INSTRUMENT INTERFACES AND REQUIREMENTS

The TRMM Observatory subsystem and instruments interfaces are as specified in each of the observatory to instrument and subsystem Interface Control Documents (ICD's). These documents define the detailed constraints and requirements for all TRMM subsystem and instrument interfaces.

2.4 TRMM OBSERVATORY WIRING HARNESS

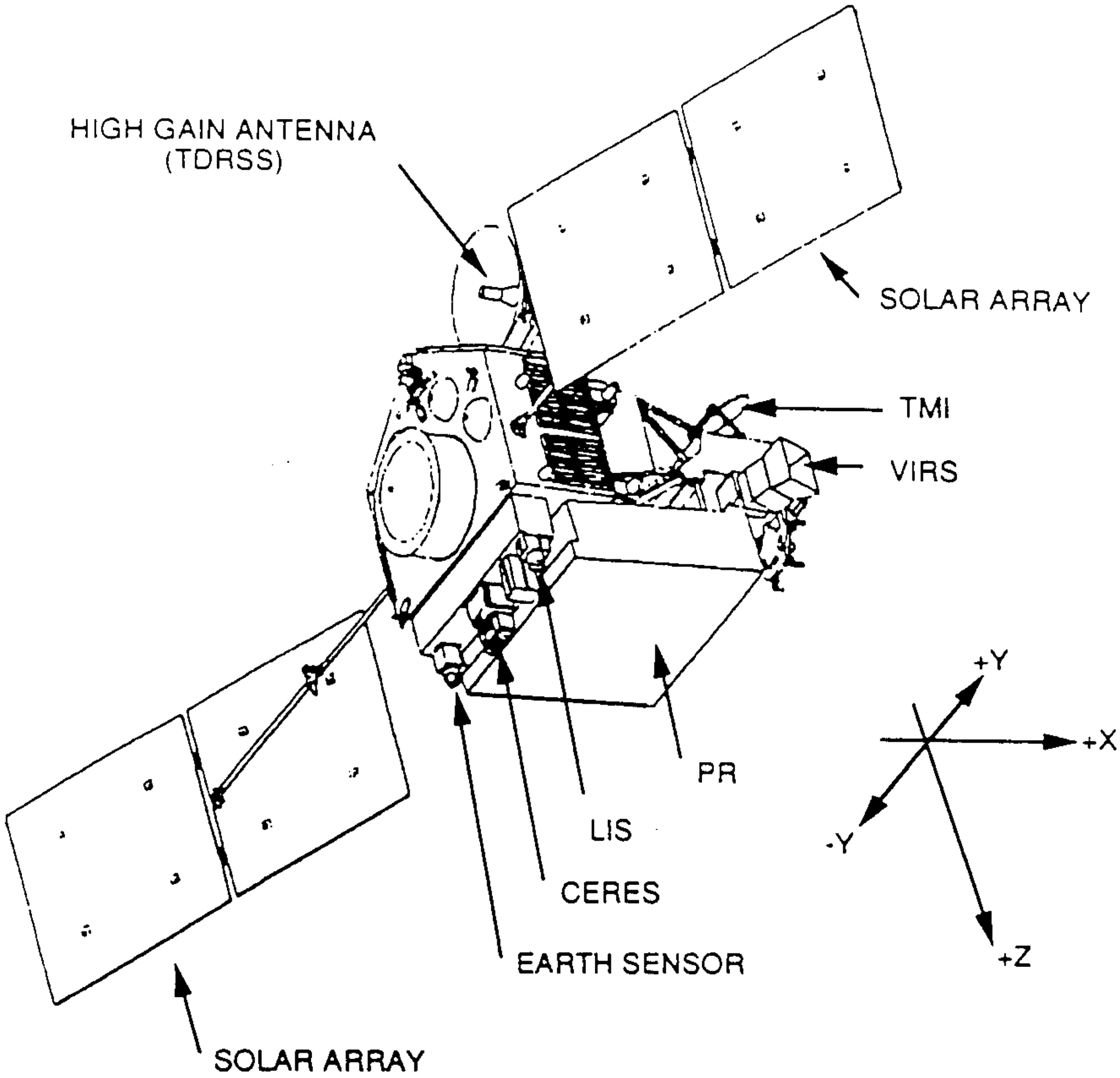
The TRMM Observatory flight electrical harness design, fabrication, and verification shall be the responsibility of GSFC Code 733. At certain stages of fabrication, milliohm and insulation resistance verification shall be witnessed and verified by a Quality Assurance (QA) representative. Only configuration control approved drawings will be used for the fabrication and verification.

Likewise, the TRMM Observatory flight optical fiber harness design, fabrication, and verification shall be the responsibility of GSFC Code 733. The fabrication process and the final product shall be verified by QA. Also, before each individual optical fiber cable is used, it will be measured to determine that its attenuation is satisfactory.

The TRMM Observatory flight RF harness will be designed, fabricated, and verified out-of-house. GSFC Code 737 has the responsibility of providing the TRMM Project with a fully qualified flight RF harness.

2.5 TRMM OBSERVATORY GROUNDING

The TRMM Observatory grounding scheme will follow the guidelines stated in the TRMM Electrical Subsystem Specification, document TRMM-733-043.



NOMINAL AXES :

+X PARALLEL TO ORBITAL VELOCITY DIRECTION
- Y NORMAL TO ORBITAL VELOCITY DIRECTION
+Z NADIR DIRECTION

Figure 2-1 TRMM OBSERVATORY

3.0 RELIABILITY, QUALITY ASSURANCE, SAFETY, AND SPECIAL CONSIDERATIONS

The purpose of this section is to give an overview of the role Reliability and Quality Assurance plays during the TRMM I&T effort. An addition purpose for this section is to make one aware and knowledgeable of safety and other special considerations during the TRMM I&T effort.

3.1 QUAILTY ASSURANCE

The TRMM I&T effort will comply with the TRMM Assurance Implementation Plan, document TRMM-303-015 and the TRMM Verification Plan, document TRMM-750-113.

3.1.1 QUALITY ASSURANCE WITNESSING AND MONITORING

During many TRMM I&T activities, QA will be required to oversee the task at hand. There are two general types of quality assurance surveillance, witnessing and monitoring. QA sign off is required for both.

- Witnessing means that the QA representative must observe all actions.
- Monitoring means that the QA representative shall be generally aware of the activities in progress and needs only to endorse particular actions as specified in the procedure

WOAs shall clearly state the level of QA surveillance required. This will be determined by the FAM during WOA review and sign off.

3.1.2 RESOLUTION OF CONFLICTS

If a dispute arises between a cognizant test engineer and the QA representative and they are not able to resolve the conflict to their mutual satisfaction, then the TRMM I&T Manager shall be consulted for a judgement in the matter. If either party is not satisfied with the I&T Manager's judgement and the matter appears irreconcilable, then the matter will be brought forward to the TRMM Observatory Manager and/or the TRMM Flight Assurance Manager.

3.1.3 CESSATION OF WORK

There may be circumstances when the QA representative will be required to issue a verbal order for all work to stop. Once given, this order shall be immediately followed by all I&T personnel. The QA representative is empowered to issue a verbal stop work order under the following circumstances:

- An immediate or potential hazard to personnel safety exists which is not adequately controlled.
- An immediate or potential hazard to flight hardware, GSE, or facilities exists which is not adequately controlled or authorized.

The incumbent with this authority has the responsibility to anticipate hazards before they arise, and to work with the test engineer or test conductor to alleviate hazards before the flow of work is impacted. This authority must not be exercised rashly because such an order could have an unanticipated negative effect on the safety of the very personnel and hardware sought to be protected. Time permitting, the preferred approach is to consult the I&T Manager and issue a stop work order with his concurrence. QA judgements of a workmanship, measurements, or procedural nature which do not present an immediate or potential hazard shall be treated in accordance with paragraph 3.1.2.

3.1.4 WOA'S AND PROCEDURES

During any TRMM I&T activity, QA personnel shall verify that approved WOAs and procedures are followed as written and that all deviations or changes are in concurrance with applicable parties and that the WOA or procedure is properly red-lined. Deviations and red-lines shall be initialed by the QA representative along with the spacecraft test conductor and the subsystem/instrument engineer.

3.1.5 LOGS, RECORDS, AND REPORTS

During any TRMM I&T activity, QA personnel shall verify that the various test team members properly document I&T actions, results, events, problems, malfunctions, etc. into the various logs, and records, and that all required reports are properly filed (see section 4.0 for more on the various logs, records, and reports and their function).

3.2 MECHANICAL HANDLING

GSFC Code 722 shall be responsible for the preparation of the TRMM Observatory Handling Plan And Procedures, document TRMM-722-TBD, which shall cover all requirements of box level, spacecraft, instrument, and observatory move and crane operations.

GSFC Code 722 personnel are responsible and shall oversee all handling and moving activities for the TRMM Spacecraft/Observatory. These activities will be performed by the TRMM Mechanical Technicians supplied by GSFC Code 750.

All handling fixtures shall be proof tested as per applicable NASA regulations and the TRMM Verification Plan, document TRMM-750-113, and the TRMM Observatory Handling Plan And Procedures, document TRMM-722-TBD.

The Operations Hazards Analysis (OHA) requirements as addressed in the applicable spacecraft moving and crane operation plans and procedures shall be followed.

Other applicable documents which shall apply are:

- TRMM Safety Plan, document TRMM-303-014
- Performance Assurance Requirements For the TRMM Mission, document TRMM-303-006
- TRMM Contamination Control Plan, document TRMM-732-016

It is required that both QA and the Contamination Control Manager (or designated representative) monitor/witness all handling/lifting of TRMM flight hardware.

3.2.1 SPACECRAFT/OBSERVATORY LOCATION MOVES

All spacecraft/observatory moves from one location to another shall be in accordance with the TRMM Observatory Handling Plan and Procedures, document TRMM-722-TBD.

3.2.2 CRANE OPERATIONS

All crane operations shall be in accordance with approved handling plans and procedures; i.e., the TRMM Observatory Handling Plan And Procedures, document TRMM-722-TBD.

Crane and lifting equipment pre-lift proof testing requirements vary dependant upon site location. At a minimum, the cranes are exercised to verify proper operation. HydraSets are exercised and proof tested within 24 hours of a lift operation involving flight hardware.

3.3 CONTAMINATION CONTROL

The TRMM Observatory contains instruments which are sensitive to both molecular and particulate contaminates. Accordingly, the TRMM Contamination Control Plan, document TRMM-732-016, has specific requirements for: the entry of personnel and equipment into the cleanroom areas; the maintenance of these areas; and the manner in which activities are conducted in these areas.

All I&T activities shall conform to the applicable contamination control requirements in the TRMM Contamination Control Plan, document TRMM-732-016. The Contamination Control Manager is responsible for assuring the implementation of the Contamination Control Plan during all I&T activities at both the GSFC and at the launch site. Personnel from all disciplines are responsible for following the requirements in the Contamination Control Plan and its supporting documents and reporting any deviations thereto to the Contamination Control Manager.

All WOAs generated for I&T activities, at the I&T Manager's discretion, shall be reviewed and approved by the Contamination Control Manager or designated representative. At a minimum, WOA's shall specify mandatory contamination control precautions, contamination control verification points or cleaning activities as required in the TRMM Contamination Control Plan, document TRMM-732-016.

The following types of I&T activities occurring either on the observatory or in its vicinity, shall require documentation on a WOA that shall be reviewed and approved by the Contamination Control Manager or designated representative:

- drilling, abrading, or other particle generating activity
- bonding, taping, painting, soldering, or other activity which requires the use of materials which can generate organic vapors through curing, evaporation, heating, or other process
- operation of mechanical or electro-mechanical equipment where moving parts may generate particles or release lubricant vapors or oily films
- any other activity where there is a potential to generate molecular or particulate contamination
- any removal or opening of spacecraft sensor or instrument aperture covers
- any other activity specified in the Contamination Control Plan, document TRMM-732-016

Demands for contamination control support for such activities as measuring cleanliness levels or cleaning GSE or flight equipment shall be made on a Contamination Control Work Order Authorization form (reference TRMM Clean Area And Personnel Operations Procedure, document TRMM-724-109).

In general, all observatory level test equipment shall be located outside of the cleanroom. When not logistically possible, it shall, at a minimum, be outside of a nine foot radius of the spacecraft/observatory. All exceptions to this requirement shall be approved by the Contamination Control Manager or designated representative.

3.3.1 PERSONNEL APPAREL

All personnel working within a cleanliness control area which contains TRMM flight hardware must be properly dressed in the required cleanroom apparel. Definition of proper cleanroom apparel, procedures for gowning and ungowning, and procedures for personnel entering and exiting a cleanroom are specified in the TRMM Clean Area And Personnel Operations Procedure, document TRMM-724-109.

3.3.2 FACILITY CLEANLINESS

The TRMM cleanroom facilities will be maintained to cleanliness levels and environmental conditions per the TRMM Contamination Control Plan, document TRMM-732-016. Guidelines, procedures, and practicies that I&T personnel are required to follow for purposes of maintaining and ensuring facility cleanliness levels are given in the TRMM Clean Area And Personnel Operations Procedure, document TRMM-724-109.

3.3.3 PURGE REQUIREMENTS

Routine nitrogen purges are required by the TMI, CERES, and VIRS Instruments once they are integrated onto the TRMM Observatory. TMI requires a nitrogen purge just prior to any actual test where the TMI Instrument will be spinning. Both CERES and VIRS requires a nitrogen purge on a more constant basis. Also, the observatory will be under a purge when being shipped to the launch site. The TRMM Contamination Control Team will be responsible for implementating required purges.

3.4 HARNESS RELATED ACTIVITIES

The electrical harness for the TRMM Observatory will be fabricated by GSFC Code 733 utilizing a spacecraft structure mockup, made of wood and sheet metal, whose dimensions, for harness fabrication purposes, match those of the flight structure. Upon completion, the electrical harness will be verified, cleaned, and baked out in accordance with the TRMM Contamination Control Plan, document TRMM-732-016, prior to integration onto the flight structure.

3.4.1 HARNESS VERIFICATION

All flight and test harnesses shall have point to point continuity measurements and insulation resistance test in accordance with the Requirements For Interconnecting Cables, Harnesses, and Wiring, document NHB-5300.4(3G), prior to initial electrical box integration tests or connection to any subsystem, instrument, or GSE.

Approved electrical integration test, using BreakOut Boxes (BOBs), shall be performed prior to mating a connector for the first time to any electrical component. Thermistors, thermostats, and other electrical devices without connectors will be handled in a manner acceptable to the Electrical Subsystem Engineer, and QA. In general, those devices will have flight approved contacts crimped onto their leads for both checkout and connection to the flight harness using mating pins (shrinkable tubing will be applied over the connection and mechanically secured in the flight configuration).

Connector mates and demates required during electrical integration, and all subsequent demates and mates may be performed ONLY by a qualified electrical technician, without re-verification as long as the following conditions are met:

- No wire changes have been made to that connector, or any connector electrically connected to that connector.

- If wiring changes have been made, only those wires affected need to be re-verified. Wires in the vicinity of the re-work shall be carefully inspected for damage. All work must be covered by WOA, and a configuration controlled drawing or waiver.

- Electrical technician and QA inspection of the connector and pins, verifying that no mechanical mis-alignments, bent pins, or broken wires, exist prior to mate.

3.4.2 HARNESS CONNECTOR SAVERS

All flight electronic box connectors shall be protected by connector savers with flight quality pins until an electrical integration procedure has been successfully completed on that connector. At that point the connector saver may be removed and the connector mated and secured with the flight approved mounting hardware. If numerous demates and mates are anticipated, the connector saver shall remain in place, and the connector will be secured by cable straps or other appropriate means. The applicable electrical integration procedure should identify frequent mate/demate connectors and specify when the connector saver may finally be removed.

Those connector savers which remain installed for day-to-day operations, shall be removed for the duration of any environmental, or other tests, which may compromise the test results.

3.4.3 BREAKOUT BOX FABRICATION AND VERIFICATION

All BreakOut Boxes (BOBs) shall be fabricated using flight quality pins (the shells may be non-flight) and configuration controlled drawings. They shall be verified as electrically correct (resistance and insulation resistance verification) by qualified electrical technicians with QA witnessing the process. A method will be implemented to label or tag each verified BOB, dated and initialed by the QA representative. Each BOB will have a serial number inscribe on it.

3.4.4 TEST AND EXTENSION CABLES

Where there is a requirement for special test cabling, particularly for the observatory level thermal vacuum / thermal balance test, or should physical layout restrictions require the fabrication of extension cables the following fabrication, verification, and contamination control requirments are applicable for any test or extension cable which makes a direct connection to any component of the observatory.

- Cables interfacing with flight components shall be fabricated using flight quality contacts; connector shells may be non-flight with the approval by Electrical Subsystem Engineer and requires QA sign off.

- Cabling between the spacecraft and the SGSE shall be provided by the EGSE Engineer; this cabling requires the approval of the Electrical Subsystem Engineer and requires QA sign off.

- Cabling between the SGSE and an IGSE shall be provided by the SGSE team; drawings shall be supplied to the Electrical Subsystem Engineer and the I&T Manager, but does not require the approval of such and does not require QA sign off.

- Cabling between an instrument GSE and the instrument shall be provided by the instrument development and test team; this cabling requires the approval by the Electrical Subsystem Engineer and requires QA sign off.

- Cables used for thermal vacuum /thermal balance tests will be fabricated in accordance with established practices for thermal vacuum cabling. This is particularly true for cables to be used inside the chamber where material selection for cables shall be in accordance with flight contamination control material selection requirements specified in the TRMM Contamination Control Plan, document TRMM-732-016. All drawings, parts, and/or equipment to be used for such tests must be reviewed and approved by the GSFC Code 754.4, the Space Simulation Test Engineering Section; these cables require the approval of the Electrical Subsystem Engineer and require sign off by both QA and the Control Control Manager.

- All test or extension cables used on the observatory or in a thermal vacuum environment shall be cleaned and baked out in accordance with the TRMM Contamination Control Plan, document TRMM-732-016 before use; requires the approval of QA, the Contamination Control Manager and the Electrical Subsystem Lead Engineer.

- Procedures shall be put in place to maintain the cleanliness of surfaces of cables which interface or come within a two foot radius of the spacecraft/observatory. When not in use, cables shall be suitably protected to prevent contamination build-ups.

- When possible test equipment should be placed and operated outside of the cleanroom. If this is not logistically possible, it shall, at a minimum, be outside of a nine foot radius of the spacecraft/observatory. Accordingly, test cables shall have adequate length to accommodate this requirement. Additionally, electrical designs shall be able to accommodate any accompanying signal losses.

- All fabrication details specified in the TRMM Electrical Subsystem Specification, document TRMM-733-043 shall be followed.

3.4.5 CONNECTOR MATE/DEMATE OPERATIONS

All connector mates and demates operations required during electrical integration, and all subsequent demates and mates may be performed ONLY by a qualified electrical technician. (A flight connector mate/demate log will be used to log all flight connector mate/demate operations, see paragraph 4.1.6).

The rectangular "D" type connectors are subject to having pins bent during the demate process unless they are demated with the tool specifically designed for that purpose. This tool shall be utilized at all times, unless the connector location makes it physically impossible to be utilized. In such cases, extreme care must be exercised to prevent side to side angular rocking of the connector during the demate process.

There is no maximum number of mates/demates for any given connector, however the number should be kept to a minimum. During each mate/demate operation the connector should be inspected by a qualified electrical technician for visible signs of damage.

3.5 SPECIAL SAFETY CONSIDERATIONS

This section addresses special safety considerations all I&T personnel should be aware of during daily I&T operations. It includes safety issues relative to both I&T personnel and flight hardware. See the TRMM Safety Document Packages: TRMM Phase 1 Safety Data Package, document TRMM-490-131; TRMM Phase 2 Safety Data Package, document TRMM-490-132; and the TRMM Phase 3 Safety Data Package, document TRMM-490-133, for more detailed safety considerations.

3.5.1 PERSONNEL SAFETY

Personnel safety is an area that cannot be emphasized enough in its importance. No compromise is acceptable when human life and limb are at risk. The TRMM I&T Manager has the primary responsibility for personnel safety, but safety is the responsibility of every individual associated with I&T. The GSFC Health and Safety Branch, GSFC Code 205.2, is located in GSFC building 17. This organization is available when questions on health and safety concerns arise. The I&T Manager and other project managers will have the authority to expand the following guidelines if required.

- The TRMM I&T Coordinator shall post Safety guidelines in the I&T areas, including emergency procedures and phone numbers.

- Flashing red and/or amber lights will be utilized in the immediate area of the spacecraft and umbilical console to indicate spacecraft power up or other critical operations.

3.5.2 PYROTECHNIC DEVICE HANDLING GENERAL SAFETY

Pyrotechnic pin pullers and separators are employed to release the HGA boom, the solar array panels, the bucket and antenna for the TMI Instrument, for opening the RCS pyrotechnic valve, and for separating the observatory from the Payload Adaptor Fitting (PAF). The responsibility for ordering, inspection, storage, handling, and testing encompasses several GSFC organizations, i.e., GSFC Codes 205, 300, 717, 722, and 733. (The TMI Instrument developer contractor will provide the pyrotechnics for the TMI bucket and antenna deployment. NASA will provide the pyrotechnics (specified by NASDA) required for the PAF separation test). GSFC Code TBD shall be responsible for preparation and implementation of the Pyrotechnic Handling Plan, document TRMM-TBD-TBD, in compliance with the GSFC Health and Safety Office, which will specify those requirements and procedures. Requirements for pyrotechnic device testing are specified in the TRMM Verification Plan, document TRMM-750-113.

3.5.3 MECHANICAL OPERATIONS SAFETY

Metal scaffolding will be employed as the means of working around the TRMM Spacecraft or Observatory. Test team members shall work in pairs, whenever possible, while working from the scaffolding. Maximum personnel weight restrictions on a given level of scaffolding will be adhered to at all times. All exterior openings shall have appropriate railings or lines to prevent personnel from falling.

During crane operations, a controlled area shall be established. Only essential personnel shall be permitted within the control area. Essential personnel will be determined by the GSFC Code 722 representative and by the QA representative. Also, during crane operations, all personnel within the controlled area shall wear hard hats. Hard hat use is normally not required for most electrical integration activities, however, their use should be encouraged at any time when personnel are working under scaffolding or mechanical structures where "heavy" mechanical work is actively in progress. Hard hat straps shall be used when working over other personnel or flight hardware. Personnel should take care never to walk or work under suspended loads for any reason. No work shall be performed under the spacecraft/observatory during lift operations.

Tools or other equipment which may fall upon personnel or flight hardware shall be tethered. This requirement shall be determined on a case by case basis.

The OHA requirements as addressed in the applicable spacecraft moving and crane operation plans and procedures shall be followed.

3.5.4 ELECTRICAL HAZARDS

All structures shall be grounded to earth ground and be verified by the lead spacecraft electrical technician, and reported to the I&T Manager. The use of ungrounded electrical/electronic equipment shall be avoided, unless addressed specifically in a work order, and approved by all responsible parties and the Electrical Subsystem Engineer for use for that particular activity or test.

If activities occur where the off/on condition of a power source is critical to the safety of the personnel involved, and is not in view of the persons involved, the source shall be monitored by another person to verify that the off/on condition is as it should be during all steps of the test. Work, other than signal verification and the like, shall not be performed while the spacecraft is powered on. Exceptions will be handled on a case by case basis, and requires approval by the I&T Manager.

3.5.5 EMERGENCY CONDITIONS

There are several categories of conditions or situations which can be classified as an emergency of varing degrees. The examples are, but not limited to, the following:

- FIRE or Medical
- Inclement Weather
- House Alternating Current Power Loss
- SGSE or IGSE Malfunction
- Facility Malfunction

3.5.5.1 FIRE OR MEDICAL EMERGENCY

In the event of fire or medical emergency at GSFC, a team member shall dial 112 on the nearest telephone and tell the operator the location, the nature of the emergency, and the number of people involved. Let the operator terminate the phone call, do not hang up first. In the event of fire, sound the building alarm and exit the area immediately. Evacuation routes for the GSFC building 7/10/15/29 complex are noted on Figure 6-1.

3.5.5.2 INCLEMENT WEATHER

Procedures shall be prepared providing step by step instructions for spacecraft or observatory safing and/or turn off, and GSE turn off in the event of inclement weather conditions such as high winds or electrical/thunder storms.

There are large visual display units throughout the GSFC building 7/10/15/29 complex mounted on walls providing good visibility. They are divided into five categories of weather conditions, with the appropriate category being illuminated. This display is controlled by the GFSC emergency console, and therefore available 24 hours a day, seven days a week. Additionally, the emergency console also provides a base wide alert network via telephone. The spacecraft test conductor(s) phone numbers, and others, will be included in this service at the start of I&T activities.

The following weather conditions are provided:

- Storm Condition 1	ALERT	(electrical/thunder storms forecasted)
- Storm Condition 2	WARNING	(electrical/thunder storms likely)
- Storm Condition 3	ACTION	(electrical/thunder storms in area)
- Storm Condition 4	ALL CLEAR	(fair weather)
- Strom Condition 5	HIGH WINDS	(high winds in area)

In general, if storm conditions 3 or 5 prevail, a determination (generally based on judgement from personal observation) will be made by the I&T Manager or his designated representative (or if not available the spacecraft test conductor) that the I&T team will cease all spacecraft powered operations until the condition improves to the satisfaction of the I&T Manager or his designated representative. At a minimum the spacecraft/observatory and EGSE shall be powered off. It is also strongly encouraged that all other GSE be powered off, i.e., SGSE, selected BGSE, and IGSEs (note that BGSE used to monitor/charge the batteries generally will remain powered, this BGSE is on an UPS system).

The GSFC building 7/10/15/29 complex environmental test facilities and cranes are generally operated during all storm conditions. It is GSFC Code 750's determination if the operation of these facilities are to cease.

The Contamination Control Manager or designated representative shall be notified immediately whenever inclement weather causes a loss of power to the cleanroom air circulation equipment or there are water leaks in the cleanroom.

Plans and procedures shall be prepared which address the appropriate actions as a result of the above warnings.

3.5.5.3 HOUSE ALTERNATING CURRENT POWER LOSS

For scheduled Alternating Current (AC) power outages, at a minimum the spacecraft/observatory and EGSE shall be powered off at some reasonable time before the outage. It is also strongly encouraged that all other GSE, i.e. SGSE, BGSE, and IGSEs, be powered off just prior to any planned power outages. There are many different circumstances and/or situations which will have to be addressed where unexpected loss of AC power can affect I&T operations. Each circumstance and/or situation requires a varying degrees of action to be taken. It will be the responsibility of the I&T Manager to provide general plans and procedures, or to see that they are in place, to handle these unexpected situations.

The Contamination Control Manager or designated representative shall be notified in advance of scheduled house power outages and immediately after unscheduled outages.

3.5.5.4 SGSE OR IGSE MALFUNCTIONS

Even though it is a highly undesired event, computers do occasionally malfunction or "crash". Typically, they can be restarted, and no action concerning the spacecraft/observatory is required, other than having the EGSE operator closely monitor the various bus currents and voltages displayed on the umbilical console. During the "down time", telemetry will be recorded on an analog tape recorder, so data being downlinked during this period can be reviewed at a later time, and if needed it can be used to restore archive records.

Should a major SGSE workstation or Front End Data System (FEDS) problem develop, it may be necessary to "safe" and perhaps turn off the spacecraft/observatory. This can be accomplished by using the Manual Command Generator (MCG). (The MCG will be supported by the UPS). Various, preloaded command sequences can be invoked to provide the required action. Essential and non-essential currents can be monitored on the umbilical console by the EGSE operator to verify proper power down.

Should an IGSE have a malfunction, the SGSE will be capable of issuing all instrument commands necessary for placing them in a safehold mode or turn off. Further, there will be sufficient instrument health and safety data monitoring by the SGSE to verify instrument status.

3.5.5.5 FACILITY MALFUNCTIONS

Should an I&T facility have an operational problem, the spacecraft/observatory may be required to be powered off until the situation is resolved.

During any I&T activity in the SCA, the Spacecraft Systems Development and Integration Facility (SSDIF), or any other contamination controlled area, if the clean room HEPA Filter Fans stop operating, the spacecraft/observatory shall be powered down in an orderly manner and all personnel shall vacate the clean room, unless directed otherwise by the I&T Manager, Contamination Control Manager, or their representatives.

The Contamination Control Manager or designated representative shall be notified immediately of all cleanroom air circulation malfunctions.

3.6 OTHER PRECAUTIONS

In order to protect the TRMM hardware and I&T personnel the following precautions must be observed by all I&T personnel.

3.6.1 GROUNDING

The spacecraft structure, work platforms and scaffolding, handrails, EGSE, etc. shall be common grounded to the local electrical quiet ground with at least one inch ground braid. The connections shall employ crimped and soldered lugs using 1/4 inch x 20 or larger bolts and nuts (unless tapped holes are available).

3.6.2 ELECTROSTATIC DISCHARGE PROTECTION

Precautions, approved materials, and practices specified in the TRMM Electrostatic Discharge Control Implementation Plan, document TRMM-733-054, shall be followed. Special case exceptions must be approved by the I&T Manager and QA prior to use. In addition, where applicable, the following QA documents shall also apply: ESD Control Plan, document P-303-840; ESD Training Requirements, document P-303-841; ESD Facilities Requirements, document P-303-842; ESD handling Requirements, document P-303-843; and Audit Of ESD, document P-303-844.

3.6.3 SOLDERING OPERATIONS

In the event that soldering is required, e.g., heaters, thermostats, etc. on, or in the close vicinity of, the flight harness or components, after the harness has been installed onto the spacecraft or observatory, ESD procedures established in the TRMM Electrostatic Discharge Control Implementation Plan, document TRMM-733-054 shall be followed. In addition, cleanliness practices and procedures established in the TRMM Contamination Control Plan, document TRMM-732-016 shall be followed. The soldering operation shall only be performed by personnel qualified for flight equipment soldering, and the operation shall be witnessed by QA.

All soldering operations will be performed per the Requirements For Soldered Electrical Connections, document NHB-5300.4(3A-2).

3.7 EGSE RELIABILITY ASSURANCE, AND HEALTH AND SAFETY MONITORING

This section defines requirements for reliability assurance and health and safety monitoring for the EGSE. In general, the EGSE is comprised of the umbilical console and electrical test equipment, but could also include subsystem/instrument test GSE and any other GSE which electrically interfaces with flight hardware.

3.7.1 EGSE FAILURE MODE EFFECTS ANALYSIS REQUIREMENT

Any EGSE which is intended to electrically connect to the spacecraft or observatory shall have the appropriate Failure Mode Effects Analysis (FMEA) performed, and any required corrective action in place, before any connection takes place.

3.7.2 EGSE RE-VERIFICATION REQUIREMENT

Any EGSE which has been disconnected from the spacecraft or observatory for test site moves, or the like, shall be re-verified per paragraph 3.7.5. A typical example would be the umbilical console/umbilical cable to the spacecraft interface to be re-verified with the use of a spacecraft load simulator prior to re-connection to the spacecraft umbilical connector.

3.7.3 ELECTRICAL TEST EQUIPMENT

Measurements will be made with test equipment carrying valid calibration stickers. This rule applies to voltmeters, ohmmeters, multimeters, current meters, oscilloscopes, and the like. Generally, all test equipment must be re-calibrated on a six month basis, or sooner if its functionality is questionable. All electrical test equipment will be calibrated per the Metrology And Calibration, document GMI/GHB-5330.8.

3.7.4 POWER EGSE MONITORING

All Direct Current (DC) power from the EGSE which interfaces with flight equipment shall be recorded on a stripchart recorder and monitored with limit sensing and alarming circuitry or software. At a minimum, the voltage output from the power supplies shall be visually confirmed as correct before connecting the EGSE rack to the flight hardware. This check shall be incorporated in a test procedure, repetitive in nature, and performed each time the rack is powered on, and before being applied to the flight equipment. Stripchart recorders will be placed across buffered output circuits to record actual voltages and currents. Stripcharts will be stored with the appropriate umbilical console operations logbook. The spacecraft test conductors shall be responsible for ensuring that power EGSE monitoring is taking place.

3.7.5 SAFE-TO-MATE CHECKS

Procedures shall be implemented to verify, as applicable, electrical continuity, isolation, and open ended voltage presence measurements on GSE cabling prior to connecting to flight hardware. These tests shall verify that the hardware is built according to signed off schematics and safe to connect to the mating interface prior to power application from the source.

3.8 MLI AND THERMAL COATINGS PRECAUTIONS

The MLI on the TRMM Observatory must be handled as little as possible. All activities should be avoided that could remove the coating applied to the MLI blankets. Remove of this coating could leave a void that would make the observatory vulnerable to atomic oxygen attack. Inspections of the MLI and this coating will be required when damage is suspected.

4.0 DAILY I&T ACTIVITIES AND CONSIDERATIONS

This section will attempt to cover most of the daily activities that may take place during I&T. Although this section covers a wide range of I&T activities it would be impossible to completely cover every situation that may occur. This document will serve as a reasonable guide to most situations. Most activities and operations will be covered by an appropriate work order authorization. Daily meetings with the TRMM I&T Manager, subsystem lead engineers, instrument managers, and other I&T support personnel will be held for information dissemination, and for planning and coordinating near term work activities. In unusual circumstances, special meetings between the I&T Manager and affected personnel will be required to resolve problems and establish work arounds.

4.1 LOGS

Many different type of logbooks will be required to provide informational and historical references during the I&T activities. These will include:

- Subsystem/Instrument Engineering Logs
- Integration Logs
- WOA, Problem Record, PFR, MRB Report Traceability Logs
- Operations Logs
- STOL Procedure Logs
- Flight Connector/Harness Mate/Demate Log
- Bonded Storage Log
- Certification Logs
- Configuration Log
- QA Logs

4.1.1 SUBSYSTEM/INSTRUMENT ENGINEERING LOG

These logs are maintained by each subsystem/instrument engineer/developer during the entire program pertaining to the development of a particular end-item.

4.1.2 INTEGRATION LOGS

The Structural Subsystem Lead Engineer may keep a log for recording all events unique to the mechanical aspects of the program. This log may also include at his discretion entries such as those included during incoming inspection. This record keeping is for the convenience of appropriate personnel, the configuration and certification logs will be the official records for this information. Electrical integration logs will be a subset of the WOA log. Electrical integration activities are also recorded in the spacecraft test conductor's logbook.

4.1.3 WOA, PROBLEM RECORD, PFR, MRB REPORT TRACEABILITY LOGS

The WOAs, problem records, PFRs, and Material Review Board (MRB) reports each shall have a status log containing sufficient information to show the current disposition of the items. Each shall contain associated WOA, problem records, PFR, and MRB report numbers for cross-referencing and traceability. (For an example of a WOA status log see Figure 4-1, WOA Status Log). The I&T CMO shall be responsible for the maintenance of these logs.

4.1.4 OPERATIONS LOGS

Operations logs serve to supplement the information in the certification logs. They are used to track key information and events performed during spacecraft and observatory I&T operations. The following are examples of these logs:

- Spacecraft Test Conductors Logbook
- Instrument Test Conductor Logbooks
- Umbilical Console Logbook

4.1.4.1 Spacecraft Test Conductor Logbook

The purposes of the spacecraft test conductor logbook are many: record the actual chronology of test events; elaborate on the data collected; record information relating to problems and/or malfunctions; record test results; communicate the status of the system from one shift of test conductors to the next; etc. The time and date shall be recorded with every entry.

The following items at a minimum shall be recorded in the spacecraft test conductor logbook.

- current date and time (time should be kept as Greenwich Mean Time (GMT) unless specified as other)
- test or activity being performed
- all pertinent events and related activities
- name (initials) of person making entry
- chronology for unexpected or unusual events
- actions performed for unexpected or unusual events
- reason for actions performed for unexpected or unusual events
- results for actions performed for unexpected or unusual events
- results of I&T activity or test
- mechanical integration/de-integration of flight hardware
- electrical integration/de-integration of flight hardware
- installation/removal of electrical/pyrotechnic bus enabling plugs
- anomalies, discrepancies, malfunctions, accidents, unforseen mishaps involving both GSE and flight hardware and software
- power on/off times of GSE and flight hardware
- procedure or event start/completion times
- shift change information
- flagrant violations of cleanroom protocol that could effect the cleanliness of the observatory

- weather conditions should it be a factor
- malfunction reports generated on any hardware or software
- flight blanket placement/removal

The spacecraft test conductors logbook shall be maintained by the spacecraft test conductors and written as events transpire. It shall be kept at the spacecraft test conductor workstation or other applicable area. A typical page of a spacecraft test conductors logbook is shown in Figure 4-2.

4.1.4.2 Instrument Test Conductor Logbooks

The instrument test conductor(s) for each instrument should maintain a logbook similar to the spacecraft test conductors logbook; similar in purpose, it should only contain information relevant to the instrument (see paragraph 4.1.4.1).

4.1.4.3 Umbilical Console Logbook

The umbilical console operators (electrical technicians) shall maintain a logbook for the umbilical console. This logbook shall be kept with the umbilical console.

'he following items at a minimum shall be recorded in the umbilical console .ogbook.

- current date and time (time should be kept as Greenwich Mean Time (GMT) unless specified as other)
- all pertinent events and related activities
- name (initials) of person making entry
- chronology for unexpected or unusual events
- actions performed for unexpected or unusual events
- reason for actions performed for unexpected or unusual events
- results for actions performed for unexpected or unusual events
- anomalies and discrepancies
- power on/off times
- weather conditions should it be a factor
- hardware configuration changes

(In addition, the Test Interface Monitor And Control Computer (TIMACC) within the EGSE will log various error conditions while the EGSE is being operated. These events will be time tagged using the EGSE time code generator.)

4.1.5 STOL EVENT LOG

All STOL entries from the SGSE workstations, either manual or from the execution of a stored file, will be logged on the STOL events printer. In addition, all instrument command requests received from the IGSEs will also be logged. This log, generated automatically by the SGSE, will be a continuous, time ordered log containing all STOL commands sent to the observatory (including command mnemonics and bit patterns), STOL procedure statements, page snaps, events, etc. This log will be an operational history for the observatory. This log will be maintained by the spacecraft test conductors.

4.1.6 FLIGHT CONNECTOR/HARNESS MATE/DEMATE LOG

A flight connector/harness mate/demate log shall be used for recording all flight connector/harness mates and demates. The connectors are prone to wear and damage and require inspections if mated and demated frequently. The log must record:

- date, time, and connector designator
- operation (mating or demating)
- item being mated to the flight connector
- electrical technician's name (initials)
- QA sign off

It is the joint responsibility of the QA representative and the electrical technician performing the task to ensure that these entries are made. The QA representative shall be responsible for maintenance of this log, and sign off of each task.

4.1.7 BONDED STORAGE LOG

A bonded storage area shall be provided for safe keeping of flight hardware (and sometimes non-flight hardware). It shall be the responsibility of the TRMM FAM and the TRMM CMO for entry into this area and the TRMM CMO shall maintain a log of all items coming in and out of this area.

4.1.8 GSFC CERTIFICATION LOGS

Certification logs shall be used to specify all of the activities that have been performed on a spacecraft component or the spacecraft itself. They will be maintained in accordance with GSFC document P-303-820, GSFC Certification Logs. (A blank certification log page is shown in Figure 4-3). One or more line items are entered on a numbered, controlled certification log page to spell out each activity performed on a unit of flight hardware. The responsible engineer is tasked with maintaining the certification log, and is responsible for making individual log entries. When a activity has been completed, the responsible engineer and the QA representative sign off in the appropriate spaces. As-run test procedures used in performing the line item are attached to the log.

Certification logs are organized in a hierarchy. As a subsystem component, such as a power converter, once it completes environmental testing and functional testing and is integrated into the next higher level of assembly, the certification log for the power converter becomes part of the next higher assembly's certification log. A notation should be made in the certification log for the higher assembly that the power converter has been accepted for integration. From this point on, the two certification logs are kept together to form one.

The certification log shall be maintained by the Hardware Developer (HD) until the end-item is officially transferred to GSFC. It will then be the responsibility of the TRMM CMO to store the log for future reference.

The certification log shall be maintained by the TRMM CMO for the TRMM Observatory. Entries shall include major events, such as integration starts and completions, box removals or installations, performance test results, and environmental test results, shipping to the launch site, etc. All entries must be signed off by QA.

4.1.9 CONFIGURATION LOG

A TRMM configuration log will be maintained by the TRMM CMO. Each component of the observatory will be listed in this log with pertinent information as listed below. It will be a current reference source to provide component tracking and also historical data. The configuration log shall at all times define explicitly the configuration of the observatory. The TRMM CMO shall be responsible for entries with the assistance from other members of the I&T and inspection teams as required. (For an example of a configuration log see Figure 4-4, Configuration Log).

- subsystem and component names
- serial and part numbers
- red/green tag item identification
- description
- activity performed (installation/removal), activity dates, associated WOA
- location where activity was performed

- weight to the nearest gram or 0.1 pounds
- applicable comments

4.1.9.1 OBSERVATORY CONFIGURATION BOARD

The use of a Observatory Configuration Board is planned for the TRMM I&T effort at GSFC. An Observatory Configuration Board is a chalk/white board which will be posted in the TRMM I&T Operations Room (building 7, room 158). This board will visually display the current hardware configuration of the TRMM Observatory, i.e., Transponder A is electrically integrated but Transponder B is not. This board will also contain other pertinent operational information, i.e., do not turn on the transmitters because the HGA is connected. The Observatory Configuration Board will be maintained and updated by the TRMM I&T Manager and/or the spacecraft test conductors.

4.1.10 QA LOGS

At the option of the TRMM FAM or a QA representative, logs may be kept for the recording of I&T and/or performance assurance related events.

4.1.11 PHOTOGRAPHIC/VIDEOTAPE LOGS

For historical reference purposes, photographs and/or video taping shall be taken at periodic times throughout the TRMM I&T program by professional photographers during major milestone activities in the TRMM Observatory build-up. Typical major milestones include the completion of electrical harness installation on the structure, subsystem integration, instrument integration, deployment test, environmental test setup, observatory shipment to the launch site, launch site activities, and launch. The TRMM I&T coordinator, with assistance from the TRMM I&T Manager shall schedule and coordinate the photographic and/or video taping of these events.

Electrical interface signals may also be photographed during integration for historical reference purposes. This would be performed at a BOB using an oscilloscope with a camera.

4.2 WORK ORDER AUTHORIZATION

The Work Order Authorization (WOA) system will commence with the installation and mechanical integration of the RCS, which is at the start of the TRMM Project Schedule Baseline Document, document TRMM-490-165. At this point, any work, integration, task, test, or activity performed on the TRMM Spacecraft or Observatory will require an approved WOA (this may also include any GSE directly connected to the spacecraft or observatory). The WOA form (Figure 4-5) shall be the main instrument for describing an overall task to be performed. The amount of actual detail on the form will be dependent on the task. It will be used to plan, schedule, and document all activities associated with the TRMM Spacecraft or Observatory and its components once delivered into the I&T flow.

WOAs may originate at any level of the organization, but shall be coordinated through the TRMM I&T CMO from preparation through completion. The I&T CMO will prepare or verify the correct preparation of WOAs, assign numbers, perform tracking and status maintenance, coordinate with the TRMM I&T Manager their execution, and ensures that the completed "as run" WOAs are maintained noting any problems or deviations. The I&T CMO will keep I&T Manager abreast of the status of all WOAs. Final archiving of WOAs will be the responsibility of the I&T CMO.

Each pending WOA shall be reviewed by the TRMM FAM and the applicable subsystem lead engineer or instrument manager. For system-level tests, the responsible manager shall replace the subsystem lead engineer or instrument manager in the sign off cycle. The WOA is then submitted to the I&T Manager and Observatory Manager for approval.

For events where the requirement for a WOA is in doubt, the I&T Manager shall make the determination.

Applicable WOA items shall be recorded on the appropriate certification log (see paragraph 4.1.8), e.g., the mechanical integration of a unit onto the TRMM Observatory shall be recorded on the certification log for that unit.

4.2.1 WORK ORDER EXECUTION

Once a WOA has been generated and approved, the work order can be executed at the I&T Manager's direction. This allows the day-to-day I&T activities to be accommodated without conflicting I&T activities scheduled simultaneously. Also, this allows all required support personnel to be notified and on duty, and allows time for all required equipment, GSE, documentation, etc. to be put into place. The completed work order shall state exactly what work was performed. This may include deviations to the original WOA (see paragraph 4.2.1.2). The subsystem or instrument representative and the QA representative shall sign the WOA on completion. The I&T Manager approves the final close out of the WOA. The completed, closed out WOA is turned over to the I&T CMO for logging its completion. After logging, it will be filed by the I&T CMO into the I&T configuration control system.

4.2.1.1 WORK ORDER AUTHORIZATION FLOW

The WOA flow diagram (Figure 4-6) provides a logical flow of events relating to the execution of a work order. It indicates the paths for personnel to take in the event of unforseen problems, required deviations, and the like. In other words, "we got an anomaly, what do we do, or where do we go from here?"

4.2.1.2 WORK ORDER DEVIATIONS

Should discrepancies in the procedure specified by the work order be discovered just prior to, or during the execution of the work order, at the discretion of the responsible QA representative, the subsystem or instrument representative, electrical or mechanical technician, and test conductor, the affected steps/parts shall be lined out or altered in red ink, and the corrections or additions shall be entered in red on the offical copy of the procedure or WOA. All applicable parties shall initial and date each change to the procedure or WOA.

The I&T Manager shall be informed (at the earliest opportunity) of the deviations, or notified in the event of a problem or suspected malfunction, and/or the requirement for a new WOA (refer to paragraph 4.2.1.1 and figure 4.6).

4.2.1.3 WORK ORDER RELATED ENCOUNTERED PROBLEMS

All problems associated with the spacecraft or observatory and any of its components (including GSE directly connected to the spacecraft or observatory) incurred during the execution of a work order shall be recorded on the GSFC Problem Record (see paragraph 4.3.1).

4.2.2 WOA AND PROBLEM RECORD TRACEABILITY

There shall be a status log for both the WOAs and the Problem Records maintained by the I&T CMO per paragraph 4.1.3 containing sufficient information for tracking and cross-referencing of WOAs, problem records, PFRs, and MRB reports.

4.2.3 NON-WORK ORDER RELATED ENCOUNTERED PROBLEMS

All problems incurred during unpowered or powered operations not related to a current work order, i.e., an unexpected problem, shall be recorded on a separate GSFC Problem Record (see paragraph 4.3.1), and the appropriate operations logs. A listing of these problem records shall be maintained in the observatory certification log. Should component removal or other work be required, entries into the appropriate subsystem certification log will also be required, and maintained as outstanding until the problem is resolved and closed. Should further investigation conclude that a hardware failure or malfunction exists, a PFR shall be written by the cognizant subsystem/instrument engineer in concurrence with the QA representative.

4.3 DISCREPANCY AND FAILURE REPORTING

All problems, malfunctions, and failures shall be documented including:

- Any departure from design, performance, testing, or handling requirements that affects the function of the flight segment or flight support equipment or could possibly compromise mission objectives (in this case a malfunction report is mandatory).

- Other problems or anomalies that are unusual, unexpected, or might affect other areas.

- Any red-line deviations from approved procedures.

Reporting is required beginning with the first power application at the subassembly level (or first operation of a mechanical item) and shall continue at increasingly higher levels of assembly and throughout integration, test, pre-launch, and post launch operations.

The TRMM FAM shall issue to the TRMM Observatory Manager and the TRMM I&T Manager on a periodic basis a status report which contains a summary of the open and closed problem records, MRB reports, and PFRs.

4.3.1 PROBLEM RECORD

Problems, unexpected events, and the like, discovered during the execution of a WOA shall be recorded on the GSFC Problem Record (see Figure 4.7), which will be located on the back, or attached to each WOA (additional sheets may be required), and in the appropriate operations log (i.e., the spacecraft test conductors logbook). (Note that the GSFC Problem Record form is on the reverse side of the GSFC Certification Log form).

The individual who discovers a problem shall immediately document the problem on the GSFC Problem Record and detail the problem in the appropriate operations log. The cognizant subsystem lead engineer/instrument manager and the QA representative shall make the initial determination as to the level of additional documentation required. A description of the problem and any initial recommendations shall be brought to the attention of the I&T Manager immediately.

Should a problem occur which is unrelated to the test being performed a separate problem record shall be initiated according to paragraph 4.2.2.

Disposition shall be as follows:

- For flight hardware, a MRB is required before rework can occur

- For non-flight hardware, if the problem can be resolved by rework to meet specifications/drawings, then the problem can be dispositioned by completing blocks 10-12 of the Problem Record

- If the problem requires repairs or a waiver, then a MRB report is required
- A PFR is mandatory for all flight hardware or software failures including intermittent or suspected failures/anomalies

4.3.2 MATERIAL REVIEW BOARD REPORT

A GSFC Material Review Board (MRB) Report (see Figure 4-8) is mandatory for all related repairs, waivers, and any other discrepancy occuring during fabrication, assembly, integration, inspection, or testing of any flight hardware component. Any out-of-specification condition which adversely affects science, performance, interfaces, cost, schedule, form, fit, function, or workmanship, causing the part to be not like the drawing or specification, will be included in this category. (For more details see the Material Review Board, document P-303-846).

The minimum membership on the TRMM MRB is as follows:

- TRMM FAM (chairman)
- TRMM Observatory Manager
- Appropriate Subsystem/Instrument Manager (or representative)

4.3.3 PROBLEM/FAILURE REPORTING

The GSFC Problem/Failure Report (PFR) form (see Figure 4-9) is the vehicle used to report problems/failures and malfunctions of flight hardware found during I&T.

PFRs shall contain the following information:

- problem/failure or malfunction
- identification of the affected hardware (by part and serial number)
- environment
- date of occurrence
- brief description of failure, cause, and corrective action

The originator is the person assigned responsibility for the item at the time the problem/failure or malfunction occurs. The originator shall attach a copy of the PFR to the certification log of the affected hardware. The PFR should be forwarded through the TRMM I&T Manager to the TRMM FAM. The FAM shall serve as the co-chairman of the Failure Review Board (FRB) and approves all members. The TRMM Deputy Project Manager is the chairman of the FRB who will represent the TRMM Project.

The FRB shall investigate, analyze, and determine the cause of all problems/failures or malfunctions occurring with flight hardware. The minimum TRMM FRB membership is as follows:

- TRMM Deputy Project Manager (chairman)
- TRMM FAM (co-chairman)
- TRMM Observatory Manager
- TRMM I&T Manager
- Subsystem Lead Engineer/Instrument Manager responsible for the failed item

FRB investigations and actions shall be coordinated with and approved by the TRMM FAM, both the TRMM Project and Deputy Project Manager, and the TRMM Observatory Manager and documented on the PFR form. Trend analysis shall be performed if necessary. The FRB will refer out-of-specification items to the MRB for disposition. Configuration changes shall be referred to the TRMM Configuration Control Board (CCB) as necessary.

Closeout of each failure shall require that:

- Verification that remedial and preventative actions have been accomplished on the applicable hardware.
- Necessary design changes in the hardware have been accomplished and verified by test(s).
- Effectivity of preventative actions have been established in other identical items of hardware.

The TRMM FAM shall sign the PFR to denote completion of closeout actions and approval of the project.

4.3.4 MRB REPORTS AND PROBLEM/FAILURE REPORTS RECORD KEEPING

Material Review Board (MRB) Reports and Problem/Failure Reports (PFRs) are generated per paragraph 4.3.2 and 4.3.3 respectively. The focal point for MRB reports and PFRs record keeping shall be the TRMM FAM. This person shall also provide a current list of the MRB reports and PFRs to the TRMM I&T Manager via the I&T CMO. A work order must be initiated to verify the fix resulting from the PFR action. Upon closing of the MRB report/PFR and the work order by the cognizant person in charge of the task, a copy of the MRB report/PFR and closed work order shall be provided to the I&T Manager and then to the I&T CMO.

4.4 WAIVER REQUEST

In some cases the original requirements for the TRMM may not be met by the flight system as built and tested. Departures from controlled documents shall be documented on the Waiver Request form (see Figure 4-10). Waiver Requests are filled out by the TRMM I&T Manager or by the responsible subsystem/instrument manager and are dispositioned by the TRMM CCB.

4.5 CONTINGENCY OPERATIONS AND TROUBLESHOOTING

Contingency operations and troubleshooting cover unexpected situations encountered during I&T. The following guidelines shall be adhered to:

- All contingency operations shall contain directions to handle unforseen circumstances. Each individual involved in an activity shall be informed of their role in a contingency situation by the responsible engineer before the activity begins.

- The first responsibility is to ensure the safety of all personnel. Once it has been determined that no personnel hazard exists, the safety of the flight hardware, GSE, and facilities shall follow.

- Record and preserve all available information including critical parameters, test procedure steps, hardware and software configuration, environmental conditions, and eyewitness accounts.

- Notify the I&T Manager, or his representative, and other appropriate personnel immediately.

- The responsible engineer may direct passive exploration of the causes, but shall not deviate from the procedure as written without approval. NO action other than the completion of necessary safing steps shall be taken until the I&T Manager, or his representative, directs the recovery from the situation with the concurrance of QA.

- All steps to be taken during troubleshooting shall be recorded in the appropriate operations log.

4.6 DAILY I&T OPERATIONS

During the TRMM I&T effort, generally the day will start off with a brief I&T meeting to discuss and plan the I&T activities for the day or the next few days. (All applicable I&T personnel should attend this meeting, see paragraph 4.6.1). Once the meeting adjourns, the appropriate I&T personnel will commence with the I&T activities planned for the day. All daily I&T operations will be specified and covered by an appropriate WOA. Generally a break will be provided for lunch if progress is being made and the planned work for the day is on schedule. The work for the day will be terminated at an appropriate stopping point. This point should consider progress and schedule along with being at a reasonable breaking point.

4.6.1 I&T MEETINGS

Just prior to the start of and throughout the TRMM Observatory I&T effort, the TRMM I&T Manager will routinely hold meetings to discuss I&T issues and to plan and coordinate the immediate I&T activities. At times these meetings will be held on a daily basis. The I&T Manager, at his discretion will schedule and coordinate these meetings. The purpose of these meetings is to discuss any outstanding work that needs to be accomplished, to discuss problems encountered and how they might be resolved, to coordinate the I&T team, to plan what I&T activities will be performed next and to prepare the required WOAs needed, to discuss any logistical conflicts or problems, etc. Generally, a responsible representative from every subsystem or instrument is required to attend these meetings if an I&T activity involving their subsystem or instrument is being planned or is underway, or if they have any problems or issues to discuss. Also, the appropriate spacecraft test conductor(s) and electrical technicians should attend these meetings along with the appropriate QA representative. The location and times of these meetings will be decided by the TRMM I&T Manager, but generally will be before any I&T activities for the day start and will be held in the TRMM conference room, building 7, room B201. In unusual circumstances, special meetings between the I&T Manager and affected personnel will be required to resolve problems and establish work-arounds.

4.6.1.1 TEST READINESS REVIEW MEETINGS

.n addition to the routine I&T meetings, the I&T Manager will hold meetings prior to each major test activity to discuss and review the test readiness. All subsystems, instruments, and other areas involved with the test will be required to attend.

4.6.2 AREAS OF RESPONSIBILITY AND STAFFING

All areas of responsibility should plan for a minimum staffing of 8 hours per day, 5 days per week during the TRMM I&T effort. However, it is anticipated that extended work hours will occur, and contingency plans requiring additional personnel should be established. It is important to note that additional staffing should be augmented by an appropriate amount of time in advance of the need for "bringing personnel up to speed" for both technical and operational requirements.

During periods of functional and environmental testing the work day/week will be extended. The extended work day might vary from 10 - 12 hours to 24 hours, while the extended work week might be extended to 6 or 7 days per week. The observatory thermal balance / thermal vacuum test will require around the clock operations for a 3 - 4 week period. Also, if the observatory I&T activities fall too much behind schedule the work day/week will be extended.

The purpose of the following sections is to define the general daily I&T activities that each group of personnel in the TRMM I&T team are required to support and to define to what extent this support is needed. This I&T support is applicable for both GSFC and TnSC, but at TnSC the level of staffing for each group may be restricted due to limited travel funding.

4.6.2.1 SPACECRAFT TEST CONDUCTOR RESPONSIBILITIES AND STAFFING

The spacecraft test conductors are ultimately responsible for being in charge and orchestrating spacecraft and observatory powered up operations. These operations include all electrical integrations and functional tests. The spacecraft or observatory will only be powered under the direction of the spacecraft test conductor(s) and will only have power removed under the direction of the spacecraft test conductor(s), even in an emergency situation. The spacecraft test conductors will be the only personnel allowed to command the spacecraft other then the Flight Operations Team (FOT) during Mission Operations Center (MOC) testing. (The MOC is formally known as the Payload Operations Control Center (POCC) and at times may still be refered to as such). The spacecraft test conductors, the FOT, and the applicable instrument test team will be allowed to command each instrument as appropriate.

During electrical integration activities the spacecraft test conductors will not only operate and control the spacecraft or observatory but will directly support the subsystem/instrument engineer with the integration task and will orchestrate the entire process. For electrical integrations, prior to having the capability to command the C&DH subsystem, only one test conductor will be required for support. He/she will be located in the SCA. For electrical integrations, once the capability to command the C&DH subsystem is obtained, one test conductor will be required in the SCA or the SSDIF to monitor the spacecraft or observatory and to orchestrate the entire electrical integration process, but a second spacecraft test conductor will be required in the I&T operations room to operate and control the spacecraft or observatory and to monitor its status throughout the entire integration process. Throughout the entire electrical integration process for the TRMM Observatory, a spacecraft test conductor's X-Terminal Workstation will be located in the SCA or the SSDIF (as needed) so the spacecraft test conductors can monitor the spacecraft or observatory from there.

During functional testing activities the spacecraft test conductor(s) will power up the spacecraft, configure it for the test, and run the STOL test procedures. Also, the test conductor will orchestrate all relative test activities and operate and control the spacecraft. If instrument testing is to be performed, the test conductor will coordinate this activity with the instrument test team(s) and will power each instrument and monitor the status of the observatory while the instrument test team(s) perform testing on their respective instrument. The spacecraft test conductor(s) will power off the spacecraft once the instruments are off and all testing is completed.

During MOC testing with the observatory, the spacecraft test conductor(s) will power the observatory and configure it to a planned configuration before handing control over to the MOC. Once the MOC has control of the observatory they will perform their test. Meanwhile, the spacecraft test conductor(s) will continue to monitor the status of the observatory and be prepared to resume control of the observatory at any time for some unforseen reason. Once the MOC testing is complete, the spacecraft test conductor will resume control of the observatory in a known configuration.

During the electrical integration or functional testing of a subsystem or a component of such, generally, the spacecraft test conductor assigned to that subsystem will be the test conductor supporting that I&T activity. This will be the case since that test conductor is most familiar with the subsystem, and is responsible for its command and telemetry data bases, page displays, and STOL test procedures. Therefore, if there are any discrepancies with the command and telemetry data bases, page displays, or the STOL test procedures for that subsystem, the responsible spacecraft test conductor will be able to take the appropriate actions.

At least one spacecraft test conductor must be on duty for all spacecraft or observatory powered operations. At various times two will be required. The lead spacecraft test conductor will be responsible for organizing test conductor coverage and schedules. Any conflicts will be handled by the TRMM I&T Manager. This spacecraft test conductor support requirement is valid for oth GSFC and TnSC.

4.6.2.2 INSTRUMENT PERSONNEL RESPONSIBILITIES AND STAFFING

The instrument managers are ultimately responsible for being in charge of their respective instrument. However, each instrument will have a test team. This test team will be responsible for overseeing and verifying the proper mechanical and electrical integration of each instrument component. Also, this includes properly testing the instrument and verifying that it is operating properly throughout the observatory environmental test program here at the GSFC and testing performed at TnSC. Basically the instrument manager is responsible for any I&T activities required to be performed on the instrument and for overseeing and directing the instrument test team.

During the mechanical integration of an instrument (or instrument component), the instrument manager or an appointed member of the instrument test team must be present to witness that the mechanical integration procedure is properly followed, that the task is properly performed, to verify the results, to approve any required deviations to the procedure, and to verify that any problems or discrepancies are noted. Basically the instrument manager is to oversee the entire mechanical integration operation for their respective instrument.

During the electrical integration of an instrument (or instrument component), the instrument manager or an appointed member of the instrument test team must be present in the SCA or the SSDIF to participate and verify that the electrical integration procedure is properly followed, that the task is properly performed, to verify the results, to approve any required deviations to the procedure, and to verify that any problems or discrepancies are noted. Also, an appropriate member of the instrument test team will be required in the I&T operations room to operate and control the instrument using the IGSE. Basically the instrument manager is to oversee the entire electrical integration operation for their respective instrument.

During functional testing of an instrument performed throughout the TRMM environmental test program here at GSFC and during functional testing of an instrument performed at TnSC a member of the instrument test team must be present to operate and test the instrument. This includes executing the functional test procedure, verifying that the test was properly performed, verifying the results, documenting required deviations to the procedure, and verifying that any problems or discrepancies are noted. Basically the instrument test team is to perform all functional test for their respective instrument.

The instrument manager or a member of the instrument test team is required to be present for all I&T activities related to their instrument. At times these activities may require the instrument manager or a member of the instrument test team to be present for extended periods of time or for multiple work shifts. Also, the electrical integration of the instrument will require two instrument representatives along with the instrument manager, this will require that each instrument test team contain several qualified people. When no I&T activities are planned for an instrument, no instrument personnel will be required, but for contingency plans a member of the instrument team must be accessable at all times.

4.6.2.3 SUBSYSTEM ENGINEER RESPONSIBILITIES AND STAFFING

The subsystem engineer is ultimately responsible for being in charge of their flight hardware/software. This includes being responsible for overseeing and verifying the proper mechanical and electrical integration of each component in their subsystem. Also, this includes verifying that their subsystem is properly tested as specified and operating properly throughout the observatory environmental test program here at the GSFC and testing performed at TnSC. Basically the subsystem engineer is responsible for any I&T activities required to be performed on their flight hardware/software.

During the mechanical integration of a subsystem or a component of such the subsystem engineer or his representative must be present to witness that the mechanical integration procedure is properly followed, that the task is properly performed, to verify the results, to approve any required deviations to the procedure, and to verify that any problems or discrepancies are noted. Basically the subsystem engineer is to oversee the entire mechanical integration operation for their respective subsystem.

During the electrical integration of a subsystem or a component of such the subsystem engineer or his representative must be present to participate and verify that the electrical integration procedure is properly followed, that the task is performed properly, to verify the results, to approve any required deviations to the procedure, and to verify that any problems or discrepancies are noted. Basically the subsystem engineer is to oversee the entire electrical integration operation for their respective subsystem.

During functional testing of a subsystem performed throughout the TRMM environmental test program here at GSFC and during functional testing of a subsystem performed at TnSC the subsystem engineer or his representative must be present to verify that the functional test procedure is properly executed, that the test was properly performed, to verify the results, to approve and required deviations to the procedure, and to verify that any problems or discrepancies are noted. Basically the subsystem engineer is to oversee the all functional test performed for their respective subsystem.

The subsystem lead engineer or his representative is required to be present for all I&T activities related to their subsystem. At times these activities may require a subsystem engineer to be present for extended periods of time or for multiple work shifts. This would require several qualified people to representative the subsystem. For times when a subsystem is being electrically integrated or tested which requires an essential spacecraft subsystem to be powered, for example the ACS is being tested which requires the C&DH subsystem to be powered, at times the C&DH engineer will not be required to support this activity, however this will be handled on a case by case basis. When no I&T activities are planned for a subsystem and the subsystem will remain unpowered, no subsystem personnel will be required, but for contingency plans the subsystem engineer or his representative must be accessable at all times.

4.6.2.4 MECHANICAL PERSONNEL RESPONSIBILITIES AND STAFFING

TRMM mechanical personnel are responsible for performing all operations on the spacecraft or observatory that are mechanical in nature. These include the mechanical integration of components onto the spacecraft or observatory (including any required mechanical de-integrations to remove components from the spacecraft or observatory), mechanical alignments, moving, positioning, or orientating the spacecraft or observatory, setting up and performing tests on the deployables subsystem, setting up the observatory for various environmental tests, supporting various environmental tests performed on the observatory, stowing the deployables, packing the observatory for shipment, etc. In addition, TRMM mechanical personnel are responsible for developing, providing, and supporting the mechanical structure. All these areas of support provided by the mechanical personnel will be required throughout the TRMM I&T effort here at the GSFC and at TnSC.

TRMM mechanical personnel can be divided into two groups: (1) mechanical engineers, and (2) mechanical technicians. The function of the mechanical technicians is to assist and support the mechanical engineers. They work as a team to perform the mechanical functions noted in the paragraph above. Generally, mechanical personnel are only required to be present to support an I&T activity that is mechanical in nature. Depending on the activity, the level of mechanical support will be determined. Generally, all I&T activities that are mechanical in nature will be scheduled in advance so the appropriate mechanical staffing can be arranged. When no operations that are mechanical in nature are planned, no mechanical personnel will be required, but for contingency plans a responsible member of the mechanical team must be accessable at all times.

4.6.2.5 ELECTRICAL TECHNICIAN RESPONSIBILITIES AND STAFFING

The TRMM electrical technicians are responsible for performing all operations on the spacecraft or observatory that are electrical in nature. These include mating/demating connectors, installing/removing all BOBs, making electrical measurements, making harness corrections, repairs, and modifications, and etc. Also, the electrical technicians will be responsible for operating and monitoring the EGSE throughout the TRMM I&T effort. In addition, the electrical technicians will build any test cables, connectors, electrical jumpers, etc. required throughout the TRMM I&T effort. All these areas of support provided by the electrical technicians will be required throughout the TRMM I&T effort here at the GSFC and at TnSC.

During the mechanical integration of any subsystem or a component of such an electrical technician shall be present to support this activity. This support includes performing the measurement between the component and the spacecraft structure for verifying a good electrical bond, verifying proper harness connector alignment, and resolving any harness interference problems, etc.

During the electrical integration of any subsystem or a component of such, an electrical technician will be required to support this activity. As mentioned above, he/she is required to perform all operations which are electrical in nature. A second electrical technician will be required to operate and monitor the EGSE.

During all functional testing activities of the TRMM Spacecraft or Observatory here at GSFC and at TnSC, electrical technicians will be required to support this activity. One electrical technician will be needed continuously when the spacecraft or observatory is powered to operate and monitor the EGSE.

The plan is for a minimum of three full time electrical technicians to support the TRMM I&T effort. During most operations, other than electrical integration, only one technician will be directly involed with I&T operations at a time. During these times the other technicians should be building any test cables, electrical jumpers, etc. which will be required in the near term. During periods of extended testing, for example thermal balance / thermal vacuum which requires around the clock operations, the electrical technicians will be required to work in shifts to provide continuous coverage.

4.6.2.6 QA PERSONNEL RESPONSIBILITIES AND STAFFING

Generally, the TRMM FAM will require that a member of the QA team be present when any activity is being performed on the spacecraft or observatory. These activities include all mechanical and electrical integrations, any mechanical operations including moving or repositioning the spacecraft or observatory, firing pyrotechnics and deployment test, and during functional and environmental testing of the observatory. Generally, the role of the QA representative during these activities is to witness or monitor the task at hand, to verify the task is being performed properly, that the WOA and any procedures are properly being followed and executed, that and deviations to the WOA or procedure are noted, that actions and results are documented, and that any problems are properly recorded. Also, the QA representative shall monitor flight test setup and recording of test data.

At times during these activities a QA representative may not be available to support an I&T activity. The QA representative may allow the work to be performed without their presence, or give specific instructions what work can be performed or that no work shall be performed. Also, at anytime during an I&T activity the QA representative can halt or terminate an I&T activity.

QA personnel should be staffed such that their presence will be adequate to provide the coverage required without causing any unnecessary work stoppages n the spacecraft or observatory. It is expected at times spacecraft or observatory operations will be performed around the clock, this will require at least several QA people. QA should not only plan on staffing I&T activities here at GSFC but also at TnSC.

4.6.2.7 CONTAMINATION CONTROL PERSONNEL RESPONSIBILITIES AND STAFFING

Once the spacecraft is ready for its initial cleaning, scheduled early in the TRMM integration flow, contamination control personnel will be required to support all TRMM I&T activities here at GSFC and at TnSC with a few exceptions. (An example of an exception is when the observatory is under vacuum during thermal balance / thermal vacuum testing, however the Contamination Control Manager or designated representative shall still be on-call). Contamination control personnel are responsible for ensuring that all aspects of the TRMM Contamination Control Plan, TRMM 732-016, are followed and maintained, and that other I&T personnel follow the same.

During integration and some functional tests, the observatory will be located in either the SCA or the SSDIF. Both the SCA and the SSDIF are cleanliness controlled areas. Throughout the TRMM I&T effort, when these areas are in use by the TRMM Project, contamination control personnel will ensure the cleanliness, at all times, of all items in this area (including the spacecraft or observatory itself). Also, all items must be cleaned prior to entry into the SCA or the SSDIF. Personnel entry into the SCA or the SSDIF will be controlled.

During environmental testing when the observatory is to leave the SCA or the SSDIF, contamination control personnel will properly ensure the contamination free transport of the observatory to its new location and that the proper precautions are made to ensure the observatory cleanliness at its new test location.

The level of staffing required depends on schedule cleanings, the level of I&T activities, observatory moves, test being performed, and the test facility. The Contamination Control Manager and designated representatives shall be an integral part of the I&T team. The I&T Manager shall assure that the Contamination Control Manager has timely notification of all scheduled and non-scheduled activities to assure that adequate staffing can be maintained.

4.6.2.8 SGSE HARDWARE/SOFTWARE PERSONNEL RESPONSIBILITIES AND STAFFING

Both SGSE hardware and software personnel will be required to set up and checkout the SGSE prior to the start of the TRMM I&T effort at both the GSFC and at TnSC. Once the SGSE is set up, checked out and operational both SGSE hardware and software personnel will be required to be available continuously when the TRMM Spacecraft or Observatory is being operated. The names and telephone numbers (including pocket pagers) for the appropriate SGSE hardware and software personnel must be given to the spacecraft test conductors so that they can be contacted if the need arises. Also throughout I&T, SGSE hardware and software personnel will be required to support various task involving the SGSE, e.g., the integration of an instrument to the SGSE.

4.6.2.9 EGSE HARDWARE/SOFTWARE PERSONNEL RESPONSIBILITIES AND STAFFING

Both EGSE hardware and software personnel will be required to set up and checkout the EGSE prior to the start of the TRMM I&T effort at both the GSFC and at TnSC. Once the EGSE is set up, checked out and operational both EGSE hardware and software personnel will be required to be available continuously when the TRMM Spacecraft or Observatory is being operated. The names and telephone numbers (including pocket pagers) for the appropriate EGSE hardware and software personnel must be given to the spacecraft test conductors so that they can be contacted if the need arises. Also throughout I&T, EGSE hardware and software personnel will be required to support various task involving the EGSE, e.g., moving the umbilical console from one test location to another. In addition, the EGSE hardware and software personnel will be required to train the electrical technicians with the operation of the EGSE.

4.6.2.10 OTHER PERSONNEL RESPONSIBILITIES AND STAFFING

Throughout the TRMM I&T effort here at the GSFC and at TnSC, various groups of other personnel will be required to support this effort. These groups might consist of environmental test directors, I&T and project management, review teams, etc. The I&T Manager and project management will determine who these groups are and will specify their level of support as the need arises.

4.6.2.11 FACILITY PERSONNEL RESPONSIBILITIES AND STAFFING

Throughout the TRMM I&T effort here at the GSFC and at TnSC, various test facilities will be required (for example the SES here at GSFC). Various facility personnel might be required to maintain, support, and operate each test facility. Here at the GSFC, the Environmental Test Engineering and Integration Branch, code 754, will specify the usage of each required facility. Hence, the GSFC personnel that operate these facilities will determine their staffing needs. At TnSC, the I&T Manager will provide input about the usage of the TnSC facilities. From which, the TnSC personnel that operate these facilities will determine their staffing needs. The TRMM I&T Manager shall be made aware of any facility staffing conflicts.

4.6.2.12 BATTERY PERSONNEL RESPONSIBILITIES AND STAFFING

The battery engineer must be notified prior to whenever batteries are to be connected to the spacecraft power bus so that this operation can be monitored or witnessed. Notification can be to either the battery engineer, the Power Subsystem Lead Engineer, or their designated representative as is appropriate at the time. The I&T Manager will schedule and plan near term work to be performed and will notify the Power Subsystem Lead Engineer of any pending work requiring battery operations so that the battery engineer or his designated representative can monitor or witness the battery operations as required.

4.6.3 I&T ACTIVITY SCHEDULING

Detailed I&T activity scheduling and tracking is the responsibility of the TRMM I&T Manager. He is required to follow the overall planned TRMM I&T flow and to maintain schedule. Also, he is required to report on progress to the TRMM Observatory Manager on a frequent basis. The subsystem and instrument managers will provide proposed daily work plans to the I&T Manager as far in advance as possible. This will allow the I&T Manager flexibility in planning I&T activities and will allow time for WOAs to be prepared and other support items to be coordinated. The I&T Manager will resolve conflicts as necessary, and issue an integrated detailed daily work schedule periodically (about each week) for the upcoming week or two.

The TRMM Project Schedule Team (GSFC Code 490) will assist the TRMM I&T Manager by developing, providing, and tracking detailed I&T activity and long term I&T schedules.

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WORK ORDER AUTHORIZATION
STATUS REPORT
OPEN WOA

WOA NO	DATE	OBJECTIVE	RESPONSIBLE PERSON	REVIEWED	APPROVED	DURATION	COMPLETION DATE	COMMENTS
0001	03/02/90	PREPARE ISP FOR MECHANICAL INTEGRATION	LEE NIEMEYER	X	X	APPROX 1 DAY 03/05	03/12/90	
0002	03/02/90	RECEIVE INSPECT/PRE-INTEGRATION MEASURE OF SP TELS	LEE NIEMEYER	X	X	APPROX 5 DAYS 03/05-03/09	03/21/90	
0003	03/02/90	FIT CHECK MLI TEMPLATES TO UPPER ISP	LEE NIEMEYER	X	X	APPROX 2 DAYS 03/06-03/07	03/09/90	
0004	03/02/90	CERTIFY ISP CLEANLINESS	BONNIE TETI	X	X	APPROX 2 1/2 DAYS 03/08-03/09	04/06/90	
0005	03/02/90	ELECTRICAL INTEGRATION PREPARATIONS	DON KIRKPATRICK	X	X	APPROX. 10 DAYS 03/02 - 03/14	03/14/90	
0006	03/02/90	CERTIFY CLEANLINESS OF PPSU	DON KIRKPATRICK	X	X	PRIOR TO 03/07	03/20/90	
0007	03/02/90	CONFIGURE EGSE FOR INTEGRATION	DON KIRKPATRICK	X	X	2 DAYS 03/08 THROUGH 03/09	03/12/90	
0008	03/08/90	MOVE DSS TO RFI ROOM	LEE NIEMEYER		X	MARCH 8 AM	03/12/90	
0009	03/09/90	BOND OPTICAL CUBE TO ISP STRUCTURE	LEE NIEMEYER	X	X	03/09/90	03/12/90	
0010	03/09/90	DSS BORESIGHT CALIBRATION	LEE NIEMEYER	X	X		03/27/90	
0011	03/09/90	CLEAN AND CERTIFY CLEANLINESS OF DSS	BONNIE TETI	X	X	03/12/90-03/13/90	03/23/90	
0012	03/09/90	DSS MASS PROPERTIES AND INTERFACE, CHECKLIST	LEE NIEMEYER	X	X	WEEK OF 03/12/90	03/20/90	
0013	03/09/90	BAG AND WEIGH UCB ELECTRONIC BOXES AND MOVE TO THE SCA	TOM HILL AND LEE NIEMEYER	X	X	03/09/90	03/12/90	
0014	03/09/90	ATTACH MLI BUTTONS TO ISP MAINFRAME	WALT ANCARROW	X	X	03/09/90	03/21/90	
0015	03/09/90	LOCK OUT CRANE ATTACHED TO SCANNER OVER WEEKEND	LEE NIEMEYER	X	X	03/09/90 THROUGH 03/11/90	03/12/90	
0016	03/12/90	REAM ALIGNMENT PIN HOLES	LEE NIEMEYER	X	X	03/12/90	03/20/90	
0017	03/12/90	REMOVE PAINT A/R INTERFERING WITH ASSEMBLY	LEE NIEMEYER	X	X	03/12/90	03/20/90	
0018	03/13/90	PURGE DS/S INSTRUMENT OPTICS	BILL DONAKOWSKI	X	X	03/16/90	03/21/90	
0019	03/15/90	MOVE 3 SCANNERS TO BACK CORNER MOVE SURFACE TABLE TO CLEAN ROOM FOR HARNESS	SHARON COOPER	X	X	03/16/90	03/20/90	
0020	03/16/90	MECHANICALLY INTEGRATE PAP HARNESS AND PAP	LEE NIEMEYER	X	X	03/19/90,03/20/90	03/30/90	
0021	03/16/90	BRUSH IRIDITE ISP MAIN FRAME	LEE NIEMYER	X	X	03/19/90	04/02/90	WILL NOT BE PERFORMED DUE TO POSSIBLE

Figure 4-1 WORK ORDER AUTHORIZATION STATUS LOG

DAVID HMASON

Day 150 5/30/89 COBE TV/TB Testing

00:17 PBIT Yellow Hi limit Failure

00:23 TFPIPFT yellow Hi limit Failure

01:09 /SELECT CU 1

01:11 /THM.DDIGHTOF DIRBE DIG "A side"
/THM.AMWHTROF ACE+MWEA1 "A side"

01:12 /SELECT CU2

01:15 /CDH.CTN2+M1
01:16 /CDH.CTN2PB1

01:17 START RION

01:21 /REC.RIFF

01:33 /REC.RISB @ Pass#4, Pos#12

01:34 START XXMION

01:38 /REC.RIPB

01:40 CITN2T Yellow hi limit Failure

01:47 /ACS.CEXSTRP2, MISMODE, AESA, BESA, CESAMBA, AXNOM, BXNOM, CXNOM

01:51 START RIOF @ BOT

01:53 START XXMIOF

01:55 /THM.DDIGHTOF

03:00 /CDH.CTNPB2

Figure 4-2 SPACECRAFT TEST CONDUCTORS LOGBOOK

GSFC CERTIFICATION LOG

PAGE ____ OF ____

1 SYSTEM/EXPERIMENT/INSTRUMENT NAME	2 PROJECT/SYSTEM	3 HARDWARE TYPE ☐ FLIGHT ☐ NON-FLIGHT ☐ GSE		
☐ COMPONENT ☐ SUB ASSEMBLY ☐ ASSEMBLY ☐ PART	5 ITEM DESCRIPTION	5A MANUFACTURER	5B DATE CODE	5C SHOP/JCS NUMBER
6 DRAWING/EEE PART NUMBER	7 REVISION/EVENT NO.	8 SERIAL NUMBER		9 QUANTITY
10 ENGINEERING APPROVAL	CODE	DATE	11 FLIGHT ASSURANCE REVIEW	DATE

12 EVENT NUMBER	13 RESP ORG CODE	14 EVENT DESCRIPTION	15 PERFORMED BY	DATE	16 INSPECTION BY	DATE	17 PROBLEM RECORD ITEM NUMBER	18 CLOSE OUT BY	DATE

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Figure 4-3 GSFC CERTIFICATION LOG

EUVE PAYLOAD MODULE FLIGHT CONFIGURATION STATUS LOG
(INCLUDING RED TAG/GREEN TAG ITEMS)

SUBSYSTEM	SER NO	PART NO	RD/GR	DESCRIPTION	ACTIVITY	DATE INST	EVTNO INST	WOANO INST	DATE REMV	EVTNO REMV	WOANO REMV	
MECH/ELEC		A1117	R	FRONT COVER INERT PYROS (NON-FLIGHT) 2 SC-A	REMOVE IN AE	/ /			/ /			
MECH			R	DETECTOR DOOR PYRO WARNING TAG	REMOVE IN AE (INSTALL FOR SHIPPING)	/ /			11/15/91	0507	0532	
MECH		D1918, C1937	R	FRONT COVER SAFETY CLAMP AND BOLT (SC-A)	REMOVE IN AE	/ /			/ /			
MECH		30-20	R	FRONT COVER SAFETY HITCH PINS (SC-A)	REMOVE ON LC17	/ /			/ /			
ELEC		GD-1509341	R	ION PUMP EXTENSION BATTERY CABLE TO PMIP J5	REMOVE IN WHITE ROOM THROUGH ACCESS DOOR	/ /			/ /			
ELEC		GD-1489138	G	PM PYRO ARMING PLUG (P1)	INSTALL IN WHITE ROOM - ACCESS DOOR (FINAL)	/ /			/ /			
MECH		D2135-2	R	BREATHER COVER - SEALING (6 PSI) (SC-A)	REMOVE IN AE	/ /			/ /			
ELEC/MECH		B2486	G	HIGH VOLTAGE ENABLE PLUGS (4 DS/S)	INSTALL IN AE	/ /			/ /			
ELEC/MECH		B2485-1	G	MOTORIZED DOOR ENABLE PLUG (RIF 4)	INSTALL IN AE	/ /			/ /			
ELEC/MECH		A1117	G	FRONT COVER PYROS (2 SC-A)	INSTALL IN AE (NON-FLIGHT INSTALLED)	/ /			/ /			
MECH		B3529	G	HV CONNECTOR CAP WITH TETHER - PMIP J6	INSTALL IN AE	/ /			/ /			
SP/ELEC	S/N NA	E0850		CDP	ELECTRICAL INTEGRATION	03/01/91	0289	0324	/ /			EU
SP/ELEC	S/N 001	E0600		DS/S	ELECTRICAL INTEGRATION	03/06/91	0294	0333	/ /			EU
SP/ELEC	S/N NA	E2604		DS/S RIF	ELECTRICAL INTEGRATION	03/04/91	0292	0329	/ /			EU
SP/ELEC	S/N 1	E2681		FUSE MODULE - A	ELECTRICAL INTEGRATION	02/26/91	285A	0334	/ /			
SP/ELEC	S/N 2	E2681		FUSE MODULE - B	ELECTRICAL INTEGRATION	02/26/91	285A	0334	/ /			
SP/ELEC	S/N NA	E3000-1		SCANNER - A	ELECTRICAL INTEGRATION	05/22/90	0074	0099	/ /			EU
SP/ELEC	S/N NA	E3000-3		SCANNER - B	ELECTRICAL INTEGRATION	05/23/90	0076	0099	/ /			EU
ELEC/PPSU	S/N 1	GE1489264		PPSU	ELECTRICAL INTEGRATION	05/01/90	0049	0079	/ /			EU
MECH/PM	S/N 1	GE-1466200		PAYLOAD MODULE ASSEMBLY	TOP ASSEMBLY	03/15/90			/ /			
MECH/PM	S/N 1	GE1466210		ISP	INSTALLATION	03/15/90			/ /			
MECH/PM	511	51450F1-1C		GRAPPLE	INSTALLATION	06/21/90	0105	0143	/ /			EU
SP/ELEC	S/N NA	E3000-2		SCANNER - C	ELECTRICAL INTEGRATION	02/01/91	0262	0295	/ /			EU
SP/ELEC	S/N NA	E0840-2		TIF A	ELECTRICAL INTEGRATION	02/28/91	0290	0326	/ /			EU
SP/ELEC	S/N NA	E0840-1		TIF B	ELECTRICAL INTEGRATION	02/28/91	0290	0326	/ /			EU
SP/ELEC	S/N NA	E0840-1		[illegible]	[illegible]	02/28/91	0291	0327	/ /			EU
SP/ELEC	S/N NA	E0840-1		TIF C	ELECTRICAL INTEGRATION	03/01/91	0291	0327	/ /			EU

Figure 4-4 CONFIGURATION LOG

TRMM Work Order Authorization

Requestor: ______________________ Ext. ________ Responsible Engineer: ______________________ Ext. ________	WOA No. ______________ Sheet ________ of ________ Date Initiated ______________ Date Work Started: ______________
Objective/Purpose:	
Subsystem Component Name, Part #, and Serial #:	Reference Drawing(s):
Task/Procedure (Itemize or attach approved procedure):	Results: (optional for detailed task)
Report/Documentation Requirements:	
ESD Control / Contamination Control Considerations: ☐ None ☐ Standard - wrist straps/contamination attire must be worn ☐ Special -	Hazards/Operational Restraints: ☐ None ☐ Photos
Remarks:	QA to: Initials ☐ Monitor ______ ☐ Witness ______ ☐ N/A ______

Reviewed By:

______________________ And/Or ______________________
Subsystem Manager Date — Instrument Manager Date

______________________ ______________________
Flight Assurance Manager Date — Systems Engineer Date

Approved: ______________________ Approved: ______________________
TRMM I&T Manager Date — TRMM Observatory Manager Date

Completed:: ______________________ Inspected/Verified: ______________________
Subsystem/Instrument Manager Date — Quality Assurance Engineer Date

Completed:: ______________________ WOA Closed: ______________________
Systems Engineer Date — TRMM I&T Manager Date

Reference WOA, PFR, MRB, CCR Numbers:	I&T CMO: Date:

Figure 4-5 WORK ORDER AUTHORIZATION

TRMM Work Order Authorization
(Continuation Sheet)

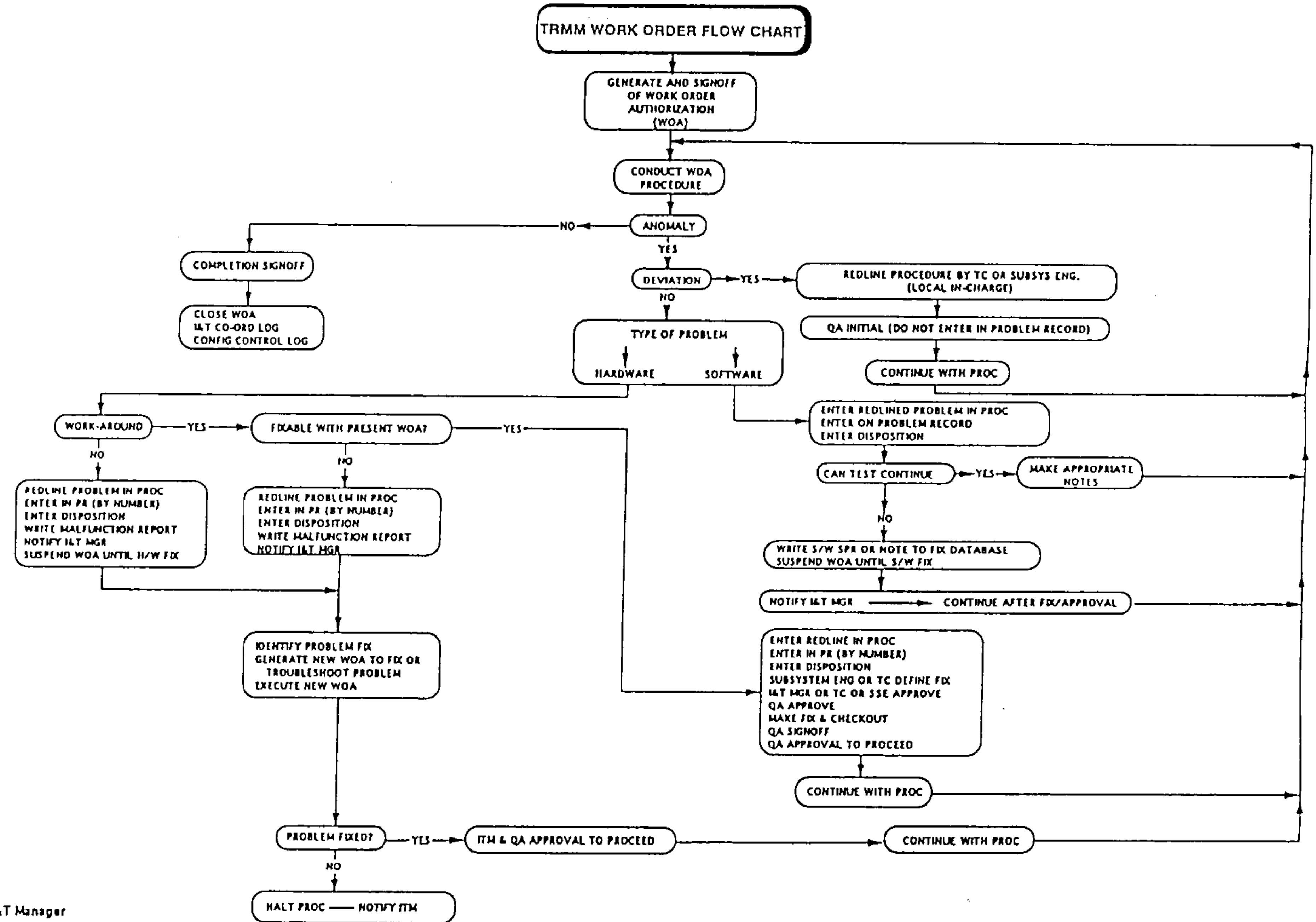
·uestor: ______________ Ext. ______	WOA No. ______________
·sponsible Engineer: ______________ Ext. ______	Sheet ________ of ________
	Date Initiated: ______________
	Date Work Started: ______________

Task/Procedure (Itemize or attach approved procedure):	Results: (optional for detailed task)

\. Continuation Authorization:

____

TRMM I&T Manager Date



NOTES:
ITM = I&T Manager
TC = Test Conductor
SSE = Subsystem Engineer
PR = Problem Record
MR = Malfunction Report

Figure 4-6 WORK ORDER AUTHORIZATION FLOW DIAGRAM

GSFC PROB 1 RECORD

PAGE ____ OF __

1 SYSTEM/EXPERIMENT/INSTRUMENT NAME	2 PROJECT/SYSTEM	3 TYPE OF HARDWARE FLIGHT ☐ GSE ☐ NON FLIGHT ☐	4 DRAWING/EEE PART NUMBER	4A REVISION	5 SERIAL NUMBER	6 QUANTITY

7 NUMBER		8	9 FOUND		10	11 CORR ACTION PERFORMED		12 FLIGHT ASSURANCE	
EVENT	PROBLEM ITEM	PROBLEM DESCRIPTION	BY	DATE	DISPOSITION AND APPROVAL	BY	DATE	ACCEPT	DATE

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Figure 4-7 GSFC PROBLEM RECORD

GSFC MATERIAL REVIEW BOARD REPORT

1 SYSTEM/INSTRUMENT	M R B	2 DISCREPANCY DATE	3 SPACECRAFT	4 PROJECT

5 IDENTIFICATION

ITEM NAME	DRAWING NUMBER	SERIAL NUMBER	MANUFACTURER
			MFR. P/N DATE CODE

6 FOUND DURING: ☐ RECEIVING ☐ FABRICATION ☐ ASSEMBLY ☐ INSPECTION ☐ TESTING ☐ AUDIT

7 HARDWARE LEVEL: ☐ PART ☐ ASSEMBLY ☐ SUBSYSTEM ☐ SYSTEM ☐ GSE ☐ EEE PART/DEVICE ☐ SUBASSEMBLY ☐ COMPONENT ☐ SPACECRAFT ☐ FACILITY ☐ OTHER

8 REFERENCE: EVENT/PROBLEM RECORD ITEM NUMBER

9 DESCRIPTION OF THE DISCREPANCY: DISCREPANCY CODE D

10 CAUSE OF THE DISCREPANCY: CAUSE CODE C

11 DISPOSITION INSTRUCTIONS:

11A DISPOSITION TYPE:
☐ DESIGNATE AS NONFLIGHT
☐ REPAIR
☐ SCRAP
☐ REWORK
☐ USE-AS-IS
☐ RETURN TO SUPPLIER
☐ PERFORM ADDITIONAL TEST
☐ WAIVER NUMBER: ____________

☐ ADDITIONAL INSTRUCTIONS ON CONTINUATION SHEETS

12 MRB DISPOSITION APPROVAL SIGNATURES

FRACTURE CONTROL COORDINATOR	DATE	PARTS MANAGER	DATE
COGNIZANT ENGINEER	DATE	PROJECT MANAGER	DATE
PROJECT SAFETY ENGINEER	DATE	ASSURANCE MANAGEMENT REPRESENTATIVE	DATE

13 CORRECTIVE ACTION: ☐ FAILURE ANALYSIS REQUESTED REPORT NUMBER: ____________ ☐ CORRECTIVE ACTION REQUEST ISSUED REQUEST NUMBER: ____________

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EXHIBIT A

Figure 4-8 GSFC MATERIAL REVIEW BOARD REPORT

Block 1 – Enter the System/Instrument name in the first portion of the block and the MRB Control Number in the last part of the block. All EEE part/device MRB numbers are to be preceded by the letter "E". (example: | F | I | R | A | S | | | | | | | - | M | R | | | E | 0 | 0 | 1 |). Enter the MRB control number in oblem Record, Block #10.

Block 2 – Enter the date that the discrepancy was found.

Block 3 – Enter the Spacecraft name and applicable letter designation (ex. GOES K) which is associated with the hardware.

Block 4 – Enter the Project name responsible for the hardware (ex. SSP).

Block 5 – Enter the appropriate "Identification" information detailing the discrepancy by the "Name", applicable "Drawing Number", "Serial Number", "Manufacturer's Name", Manufacturer's Part Number and Date Code (if applicable).

Block 6 – Enter when the discrepancy occurred.

Block 7 – Enter the hardware level at which the discrepancy occurred.

Block 8 – Enter the Problem Record Item number.

Block 9 – Describe the discrepancy in detail. Use the MRB Report [illegible]nuation Sheets, if needed. The description MUST be under[illegible]ble, legible and complete, because this description is used as a historical record. Enter the most appropriate code in the Discrepancy Code blocks. See Discrepancy Code list in Table A. Both the AMR and Cognizant Engineer must sign the MRB Report.

Block 10 – Describe in detail the cause of the discrepancy. Enter the most appropriate code in the Cause Code blocks; see Cause Code list in Table B.

Block 11 – Enter detailed disposition instructions. (Use MRB Report Continuation Sheets if more space is needed.)

Block 11A – Indicate the Disposition Type; include the Control Number for any Waiver(s) initiated.

Block 12 – Check the boxes if the Fracture Control Coordinator and/or System Safety Manager is required, have them review the MRB, and sign the report for disposition approval. The AMR and Cognizant Engineer shall sign the MRB Report for disposition approval and attach a copy to the Certification Log for implementation. Retain the original MRB form with the MRB log. For EEE parts/Devices the Parts Manager will sign the Cognizant Engineer Block.

[illegible] 13 – The Assurance Management Representative will enter [illegible]pplicable Failure Analysis Report Number and appropriate Corrective Action Request Number

EXHIBIT A REVERSE

GSFC DISCREPANCY CODES

SOLDER

DS1 Cold Solder Joint
DS2 Overheated Connection
DS3 Excess Solder
DS5 Insufficient Solder
DS6 Other

WIRING

DW1 Wired Incorrectly
DW2 Insulation/Wire Damage
DW3 Incorrect Mech Wrap
DW4 Excess Wicking
DW5 Improper Crimp
DW6 Other

EEE PART/DEVICES

DA1 Damaged
DA2 Other

PRINTED WIRING BOARDS

DP1 Surface or Circuit Damage
DP2 Potential Short Circuit
DP3 Delamination
DP4 Lifted Pad
DP5 PTH Defect
DP6 Contamination
DP7 Dimensional Defects
DP8 Improper Plating Thickness
DP9 Other

ENCAPSULATION/CONFORMAL COATING

DE1 Insufficient Coating
DE2 Excessive Coating
DE3 Voids, Bubbles, Contamination
DE5 Improper Cure
DE6 Improper Mix
DE7 Other

MATERIAL

DM1 Improper Applicatio
DM2 Improper Raw Mater
DM3 Material Damaged
DM4 Expired Shelf Life
DM5 Other

MECHANICAL

DF1 Dimension Out of Tolerance
DF2 Operation Missed
DF3 Hardware Incorrectly Identified
DF4 Process Defect
DF5 Binding/Improper Fi
DF6 Tooling Damage
DF7 Incorrect Hardware
DF8 Hardware Damaged
DF9 Other

DT1 OTHER

Table A

GSFC CAUSE CODES

C01 Operator Error
C02 Fabrication Error
C03 GSE Failure
C04 Part Failure
C05 Handling
C06 Drawing Error
C07 Incorrect/Incomplete Drawing
C08 Incorrect/Incomplete Procedure/Instructions
C09 Unknown
C0A Other

Table B

MRB REPORT CONTINUATION SHEET

1. SYSTEM/INSTRUMENT	M R B	2. DATE	3. PAGE OF

GSFC 4-32 A (12/90)

EXHIBIT B

PROBLEM / FAILURE REPORT

(1) TEST ELEMENT FLT [ ] HDW [ ] SW GRD [ ] HDW [ ] SW TEST [ ] HDW [ ] SW | PFR No | Contactor Report No

(2) Project | (3) Spacecraft/Observatory | (4) Operating Time | (5) No. of Cycles

Sub-System/Instrument | (7) S/W Version | (8) Date & Time of Problem/Failure: Yr | Mo | Day | Time | (9) Date of Report: Yr | Mo | Day

(10) Originator (Last Name, First Name) | Phone (xxx/yyy-yyyy) | Organization (GSFC Code or Company)

(11) Run Test ID

(12) Supporting Information [ ] Console Printout [ ] Dump Printout [ ] Error Codes [ ] ________ Dump Tape No [ ] Criticality [ ] Other

(13) Problem/Failure Occurred During [ ] Bench/Unit Test [ ] Qualification Test [ ] Integration Test [ ] Acceptance Test [ ] Pre-Launch Operations [ ] Launch Operations [ ] Other

(14) Environment When Failed [ ] Acceleration [ ] Shock [ ] Thermal-Vacuum [ ] Temperature [ ] Humidity [ ] Vibration [ ] Ambient [ ] Vibration [ ] EMI/EMC [ ] Magnetics

(15) Hardware Integration Level When Failed [ ] Part [ ] Sub-Assembly [ ] Assembly [ ] Component [ ] Spacecraft Sub-system [ ] Instrument Experiment [ ] Spacecraft/Observatory

(16) Software Integration Level When Failed [ ] OS [ ] User Interface [ ] Database [ ] Driver [ ] Communications [ ] Firmware [ ] Term [ ] Other

	NAME	IDENTIFICATION/REVISION NO	SERIAL NO	MANUFACTURER	CAGE CODE
(17) Component					
(18) Assembly					
(19) Sub-Assembly					
(20) Part		Manufacturer's Part Number	Date Code		

(21) Description of the Problem/Failure (attach additional sheets if necessary)

(22) Reference Certification Log Book # ________ Page ________ Test Procedure ________ Para ________

(23) Cause of the Problem/Failure (attach additional sheets if necessary)

(24) Correction Action Taken (attach additional sheets if necessary)

(25) If Corrective Action is Required on Other Units, List Units by Serial No

(26) Failure Analysis Performed [ ] Yes [ ] No [ ] N/A | Failure Analysis Performed by GSFC Code Contractor ________ Failure Analysis Report Number ________

(27) Action Taken on Failed Unit [ ] Rework [ ] Modified [ ] Discard [ ] Replace [ ] None [ ] PSMB/CCB [ ] Submit to MRB
Organization That Performed Rework/Repair ________ MRB No ________ Date: ________

(28) Is Retest Required After Corrective Action? [ ] Yes [ ] No If Yes, State Retest Requirements | Date Completed

(29) Is Unit Suitable for Original Use. [ ] Yes [ ] No Remarks

(30) Contractor Program Manager FRB Approval
Signature ________ Date: ________
QA Signature ________ Date: ________

(31) Safety [ ] (32) Failure Effect Rating [ ] (33) Failure Corrective Action Rating [ ] (34) Red Flag [ ] Yes [ ] No

(35) GSFC Project Manager Approval | Date | (36) GSFC OFA Approval | Date Closed

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Figure 4-9 PROBLEM/FAILURE REPORT

WAIVER REQUEST

TRMM PROJECT

Date Prepared:	Waiver No:
Initiated By:	
ITEM AFFECTED: P/N: Name: Serial/Lot:	SYSTEM AFFECTED: P/N: Name:

Original Requirements:

Waiver Requested:

Justification/Reason:

Related Action and Effect:
(include cost/price)

FUNCTION	APPROVAL SIGNATURE	DATE
Originator		
HD Manager		
Principal Investigator		
GSFC Instrument Manager		
TRMM Instrument System Manager		
TRMM Observatory Manager		
Flight Assurance Manager		
TRMM Project Manager		

Figure 4-10 WAIVER REQUEST

5.0 HARDWARE RECEIVING AND INSPECTION

The HD is responsible for the preparation of handling, shipping, inspection procedures, and the Acceptance Data Package with the delivery of end-items as specified in the TRMM PAR, document TRMM-303-006. The HD shall make prior arrangements through the appropriate instrument or subsystem manager for delivery and required assistance during hardware receiving and inspection activities. The TRMM I&T Manager will also provide needed assistance. If required, the TRMM Project Support Manager (GSFC Code 490) is responsible for security clearance arrangements for HD personnel and the hardware itself. GSFC QA shall witness all receiving and inspection activities and shall validate all certification logs as evidence of inspection activity verification.

(Applicable to the TRMM instruments: for detailed hardware receiving and inspection plans see the appropriate appendix for each respective instrument, also see Figure 5-1 for a preliminary flow diagram of the receiving and inspection activities for the instruments).

5.1 HARDWARE RECEIVING AREAS

One of the GSFC building 7/15/29 trucklocks (preferably the GSFC building 29 trucklock) shall be used as the initial receiving area for large items such as GSE or crated hardware. The items will be unloaded from the truck using either lifting slings provided by the HD or by forklift. (Lifting slings must be certified prior to being used. The certification of a lifting sling provided by the HD will be accepted by GSFC if it is current and performed to GSFC requirements. Lifting slings must be tagged with the current certification certificate). (See section 6.0 for the locations of trucklocks and other I&T facilities).

5.2 HARDWARE VISUAL INSPECTION

After unloading the hardware, it shall be unpacked, uncrated, and visually inspected per the requirements of the Contamination Control Plan, document TRMM-732-016. Under no circumstances shall hardware surfaces be exposed to environments which do not meet the hardware's minimum cleanroom requirements. For example exterior crates may be removed in a semi-cleanroom, but interior packing materials shall not be removed or opened until the item has been relocated to a cleanroom of the appropriate cleanliness.

The hardware will then be moved to the appropriate area for further inspection and checked for cleanliness. The following items shall be included in the incoming visual inspection, and performed by the appropriate personnel per paragraph 5.6.

- Determine ESD susceptibility and verify correct markings. If susceptible, insure that proper handling procedures are followed per the TRMM ESD Control Implementation Plan, document TRMM-733-054, prior to continuation of the inspection.

- Log and verify correct serial numbers, part numbers, and manufacturer.
- Inspect the shipping container for physical damage, and the integrity of seals.
- Inspect the end-item for physical damage.
- Verify surface cleanliness levels per the TRMM Contamination Control Plan, document TRMM-732-016.
- Check and verify mechanical (i.e. mounting surface(s)), electrical (i.e. number and size of connectors), and thermal (i.e. MLI interferences) per specified interface requirements (ICD)
- Check connectors and pins for evidence of damage or contamination.

5.2.1 GROUND SUPPORT EQUIPMENT

Once inspected for damage, if any GSE is required for the hardware acceptance test, it should also be delivered to the appropriate area along with the Subsystem or Instrument, otherwise, it can be delivered to the designated operations area depending upon its purpose.

5.2.2 PHOTOGRAPHIC/VIDEOTAPE COVERAGE

Photographic and/or videotape coverage should be utilized to provide documentation and an historical record for any Subsystem or Instrument where damage is found during receiving and inspection.

5.3 SUBSYSTEM ACCEPTANCE TEST

At the conclusion of receiving and inspection activities for the subsystems, if any acceptance test is to be performed, the Subsystem Manager (or his representative) will proceed to configure any required GSE, and the subsystem for acceptance testing (assuming no problems or discrepancies were found during receiving and inspection). This test setup should be configured the same as it was at the facility where the hardware was developed.

5.4 INSTRUMENT ACCEPTANCE TEST

At the conclusion of receiving and inspection activities for the instruments, the Instrument Manager and the Instrument Test Team will proceed to configure the IGSE, any other required GSE, and the instrument for acceptance tests (assuming no problems or discrepancies were found during receiving and inspection). This test setup should be configured the same as it was at the facility where the instrument was developed.

5.5 LOGS

The receiving and inspection process shall include several logbooks, as noted in section 4.1, which provide a written history of the end-item.

The certification log shall be the offical log of record for each receiving and inspection activity. This shall also be the initial entry into the I&T configuration log (maintains current location and status of all flight hardware). Entries in the other logs shall be the responsibility of the appropriate managers/engineers, for informational and historical records.

5.6 RESPONSIBILITIES

The following designates the personnel required, and their associated responsibilities, for each end-item receiving and inspection activity.

a) I&T Manager - to provide needed assistance during the entire receiving and inspection process

b) Subsystem or Instrument Manager - oversee the entire receiving and inspection process (including any acceptance testing) for their subsystem or instrument, and to sign off any shipping/receiving documents.

c) TRMM Configuration Control Officer - responsible for maintaining the Configuration Log.

d) Electrical Subsystem Engineer - overall in charge of electrically related items, such as connector/pin handling and inspection, and ESD control, e.g., proper grounding of equipment and personnel, per the TRMM ESD Control Implementation Plan, document TRMM-733-054. Also, to check and verify electrical interface (i.e. number and size of connectors) per the ICD

e) Structural Subsystem Engineer - overall in charge of moving, handling, and any mechanically related activities. Also, to check and verify mechanical interface (i.e mounting surface(s) and MLI interferences) per ICD

f) Quality Assurance - verify that all procedures are followed as written or with appropriate deviations, all operations are performed in a safe manner, and sign off of the Certification and Configuration Logs, and shipping documents.

g) Contamination Control Manager - responsible for certifying the cleanliness of the end-item, and logging all discrepancies in the Certification Log, also shall witness/monitor all receiving activities for the TRMM Instruments

h) Electrical Technicians - provide as needed assistance during the inspection process.

i) Mechanical Technicians - will assist in unloading, perform moving and handling, and operate crane/forklift.

5.7 POST RECEIVING AND INSPECTION

At the conclusion of receiving and inspection activities and any acceptance test (if applicable), if required the flight hardware will be cleaned per the TRMM Contamination Control Plan, document TRMM-732-016, prior to being placed into the SCA or the SSDIF for mechanical integration onto the TRMM Observatory. Likewise, any IGSE will be moved into the TRMM I&T Operations Room, building 7, room 158, for integration with the SGSE. In addition, any other instrument or subsystem unique GSE will be move to the appropriate location or stored in an area determined on a case by case basis. Any required GSE must be cleaned per the TRMM Contamination Control Plan, document TRMM-732-016, prior to its entry into the SCA, the SSDIF, or any other cleanliness controlled area.

5.7.1 BONDED STORAGE

At the conclusion of receiving and inspection activities and any acceptance test (if applicable), if the flight hardware is not immediately required in the SCA/SSDIF (or other applicable area) for mechanical integration onto the observatory, the flight hardware shall be placed in Bonded Storage. Bonded storage is a secure controlled access area used for temporary storage. The TRMM bonded storage area will be under the control of the TRMM FAM and the TRMM CMO. The location of this area will be GSFC building 7, room 15/15A.

INSTRUMENT RECEIVING & INSPECTION ACTIVITIES

INSTRUMENT RECEIVING ACTIVITIES

KEY ACTIVITIES:

- INSTRUMENT ARRIVES VIA TRUCK AT BUILDING 7/15/29 TRUCKLOCK (PREFERABLY BUILDING 29 TRUCKLOCK)
- INSTRUMENT PROVIDED LIFTING SLING(S) TESTED AND CERTIFIED
- INSTRUMENT / GSE UNLOADED FROM TRUCK USING LIFTING SLING(S) OR FORKLIFT

* EXPECTED ACTIVITY PERIOD - 1 DAY

INSTRUMENT INSPECTION ACTIVITIES

KEY ACTIVITIES:

- INSTRUMENT / GSE UNCRATED / UNPACKED
- INSTRUMENT / GSE SHIPPING CONTAINERS VISUALLY INSPECTED FOR DAMAGE (INSTRUMENT IS TO REMAIN BAGGED)
- RECORD /PHOTOGRAPH OR VIEDOTAPE ANY DAMAGE OR DISCREPANCIES
- LOAD GSE ONTO GSFC PROVIDED MOVING DOLLY USING LIFTING SLING(S) AND CRANE IF REQUIRED
- MOVE GSE TO JUST OUTSIDE THE "BIG TOP" CLEAN TENT IN BUILDING 10 OR TO OTHER DESIGNATED CLEAN AREA
- REMOVE GSE FROM MOVING DOLLY USING LIFTING SLING(S) AND CRANE IF REQUIRED
- LOAD INSTRUMENT ONTO GSFC PROVIDED MOVING DOLLY USING LIFTING SLINGS(S) AND CRANE
- MOVE INSTRUMENT TO JUST OUTSIDE THE "BIG TOP" CLEAN TENT IN BUILDING 10 OR TO OTHER DESIGNATED CLEAN AREA
- REMOVE OUTER CONTAMINATION COVER (BAG) AND SLIP THE INSTRUMENT INTO THE CLEAN TENT
- REMOVE INNER CONTAMINATION COVER (BAG)
- COMPLETE INSTRUMENT INSPECTION; ELECTRICAL, MECHANICAL, AND THERMAL INTERFACES TO BE VISUALLY CHECKED AND VERIFIED PER THE ICD
- CHECK THE INSTRUMENT FOR CLEANLINESS AND CLEAN INSTRUMENT IF REQUIRED

* EXPECTED ACTIVITY PERIOD - 2 DAYS

INSTRUMENT ACCEPTANCE TEST

KEY ACTIVITIES:

- SET UP INSTRUMENT FOR ACCEPTANCE TESTING
- SET UP GSE FOR INSTRUMENT ACCEPTANCE TEST (TEST CABLES ARE PROVIDED BY THE INSTRUMENT THEY SHOULD BE LONG ENOUGH TO EXTEND FROM THE GSE OUTSIDE THE CLEAN TENT TO THE INSTRUMENT LOCATED INSIDE THE CLEAN TENT, ABOUT 6 METERS, ALSO TEST CABLES TO GO INSIDE THE CLEAN TENT MUST BE COVERED OR CLEANED)
- CONNECT GSE TO INSTRUMENT
- PERFORM ACCEPTANCE TEST
- DISCONNECT GSE FROM INSTRUMENT

* EXPECTED ACTIVITY PERIOD - 4 DAYS (ASSUMING 2 DAYS FOR ACCEPTANCE TEST)

POST INSTRUMENT RECEIVING & INSPECTION ACTIVITIES

KEY ACTIVITIES:

- DOUBLE BAG INSTRUMENT
- MOVE INSTRUMENT TO SCA IF READY FOR MECHANICAL INTEGRATION ONTO THE OBSERVATORY
- MOVE IGSE TO TRMM I&T OPERATIONS ROOM
- INTEGRATE IGSE TO SGSE AND PERFORM IGSE / SGSE INTERFACE TEST (CAN BE PERFORMED IN PARALLEL WITH INSTRUMENT MECHANICAL INTEGRATION BUT NOT DURING OTHER I&T OPERATIONS)

* EXPECTED ACTIVITY PERIOD - 4 DAYS (2 DAYS OF THIS DURATION MIGHT INCLUDE THE MECHANICAL INTEGRATION OF THE INSTRUMENT ONTO THE OBSERVATORY)

TOTAL DURATION: 11 DAYS (ASSUMING 2 DAYS FOR ACCEPTANCE TEST, DURATION MIGHT INCLUDE THE INSTRUMENT MECHANICAL INTEGRATION)

NOTES: THE INSTRUMENT MANAGER IS RESPONSIBLE FOR COORDINATING THESE ACTIVITES UNTIL THE INSTRUMENT IS DELIVERED TO THE OBSERVATORY FOR INTEGRATION AND UNTIL THE IGSE IS INTEGRATED WITH THE SGSE. THROUGHOUT ALL THESE ACTIVITIES ESD AND CONTAMINATION PRECAUTIONS MUST BE IN EFFECT.

Figure 5-1 INSTRUMENT RECEIVING AND INSPECTION ACTIVITIES

6.0 GSFC INTEGRATION AND TEST FACILITIES

The TRMM Spacecraft/Observatory I&T activities will require a variety of mechanical and electrical work, assembly, and integration and testing areas. This section will provide an overview of these requirements for the GSFC. (See Figures 6-1 through Figure 6-5 for locations and layouts of various GSFC Integration and Test Facilities).

6.1 INTEGRATION FACILITIES

The TRMM spacecraft I&T activities will require various work, assembly, integration, and logistical support areas and facilities in the GSFC building 7/10/15/29 complex. This section addresses those requirements. It does not include the space required for the spacecraft harness fabrication, or other subsystem development. (See Table 6-1 for the required GSFC integration facilities and locations).

TABLE 6-1 - GSFC INTEGRATION FACILITIES AND LOCATIONS

FACILITY	LOCATION
I&T Operations Room	Building 7, Room 158
EGSE/Umbilical Console Areas	Building 7/29, High-Bay/150
Spacecraft Integration Area	Building 7/29, SCA/SSDIF
Large RF Shield Room Work Area	Building 7, SCA RF Room
Hardware/Equipment Cleaning Facility	Building 7, High-Bay Tent
Receiving and Inspection Area	Building 29, Trucklock
Instrument Acceptance Test Area	Building 10, Clean Tent
Electrical Work Area	Building 7, High-Bay
Mechanical Work Areas	Building 7/10/29, High-Bays
RCS PTM Installation Area	Building 29, High-Bay
RCS Pressure Test Area	Building 15, HCC Rotunda
RCS Mechanical Integration Area	Building 7, SCA
Initial Spacecraft Cleaning Areas	Building 29/7, High-Bay/SCA
Packing And Pre-Shipment	Building 29, Trucklock
Bonded Storage	Building 7, Room 15/15A
Miscellaneous Storage	Building 7/10/29, TBD Areas

6.1.1 TRUCKLOCKS

One of the building 7/15/29 trucklocks (preferably the building 29 trucklock) shall be used as the initial receiving, unpacking, and inspection area for large items such as GSE and crated hardware. Also, this area will be used for a staging and packing area in preparation for observatory and GSE shipment to the launch site.

6.1.2 HIGH-BAY WORK AREA

A large work area (approximately 30 x 30 feet) will be located in the building 7 high-bay, just outside of the SCA, for supporting TRMM I&T Activities. This area will be utilized for the following:

- mechanical work area
- electrical work area
- mechanical and electrical parts storage equipment storage
- inspection area
- final electrical harness work
- fabrication of test cables, etc.
- other supporting activities

In addition, mechanical work areas will be available in GSFC buildings 10 and 29 high-bays.

6.1.3 EGSE/UMBILICAL CONSOLE AREAS

During initial I&T events where the SCA is the "home base" for the TRMM Spacecraft or Observatory, an area will be reserved in the GSFC building 7 high-bay, outside and adjacent to the SCA glassed viewing wall for the placement of the umbilical console and other related EGSE and equipment.

During I&T events where the SSDIF is the "home base" for the TRMM Observatory, an area will be reserved in the GSFC building #29, room 150, which is outside and adjacent to the SSDIF for the placement of the umbilical console and other related EGSE and equipment.

Although the baseline plan is to have the umbilical console and other related EGSE outside of the SCA during initial I&T events, it will also be possible to move the umbilical console and related EGSE just inside the SCA. The advantage of during this is that it will allow the electrical technician who is operating the umbilical console and EGSE to also support I&T activities on the spacecraft. The disadvantage of doing this is that initially some minor modifications to the umbilical console and EGSE may be required which can not be performed inside the SCA. Also, there is a contamination concern having the umbilical console and related EGSE located inside the SCA. In addition, the umbilical console operator would be more comfortable outside the SCA. The same rational is true for when the observatory is in the SSDIF. However, the contamination concern inside the SSDIF is much greater. The placement of the umbilical console and related EGSE will be decided on a case by case basis.

Both of these locations will require various intra-building cabling and AC electrical services to support the EGSE/umbilical console. These services must be such that they can perform their function for either case: when the EGSE/umbilical console is in the clean room or for when it is just outside. The area required for each location outside the clean room is approximately 100 square feet.

6.1.4 CLEAN ROOMS

A clean room is defined as an area where various contamination sources are controlled below some specified limit. Clean rooms required for TRMM I&T activities include, the SCA, the SSDIF, the SCA RF shield room, the SES, and the building 10 "big top" clean tent.

6.1.4.1 SCA

The SCA, located in building 7, will be the initial mechanical and electrical integration and functional test area for the TRMM Spacecraft. It will be the "home base" for the observatory until physical constraints make it necessary to relocate the "home base" to the SSDIF. The SCA may also be a temporary storage area for flight hardware and test equipment, in lieu of the bonded storage area. The SCA will be utilized for some of the required optical alignments (see paragraph 6.2.3 and the TRMM Project Schedule Baseline Document, document TRMM-490-165). In addition, this area is baselined to be used as the RCS installation and mechanical integration area (see paragraph 6.1.8).

The SCA is a large (57 x 37 feet) horizontal laminar flow clean room capable of class 10,000 cleanliness. The room will be maintained at a level specified in the TRMM PAR, document TRMM-303-006. Requirements for personnel and items entering this area are addressed in the TRMM Clean Area and Personnel Operations Procedure, document TRMM-724-109.

6.1.4.2 SSDIF

The SSDIF, located in building 29, will be an area used by the project to perform various mechanical and electrical integration and functional test activities for the TRMM Observatory. It will become the "home base" for the observatory once physical constraints make it necessary to relocate the "home base" from the SCA. The SSDIF may also be a temporary storage area for flight hardware and test equipment, in lieu of the bonded storage area. The SSDIF will be utilized for some of the required optical alignments (see paragraph 6.2.3 and the TRMM Project Schedule Baseline Document, document TRMM-490-165).

The SSDIF is a large (125 x 100 feet) horizontal laminar flow clean room capable of class 10,000 cleanliness. The room will be maintained at a level specified in the TRMM PAR, document TRMM-303-006. Requirements for personnel and items entering this area are addressed in the TRMM Clean Area and Personnel Operations Procedure, document TRMM-724-109.

The TRMM I&T activities occurring within the SSDIF will not require the use of the entire SSDIF. Only an area of approximately 50 feet x 50 feet will be required. (Some additional areas may be required to store GSE during the solar array deployment test which is the test configuration which requires the most area). It is hoped that this area will be in the northwest corner of the SSDIF against the Hepa filters. This will allow direct access to the umbilical console and associated EGSE located just through the north end of the west wall of the SSDIF. Also, access to the large roll up door is required since the TRMM Observatory will be required to enter and exit the SSDIF several times.

6.1.4.3 OTHER CLEAN AREAS

Other clean areas required for TRMM I&T activities include the SCA RF shield room, the SES, and the building 10 "big top" clean tent.

The SCA RF shield room will not only be used to perform the observatory Electromagnetic Interference (EMI) / Electromagnetic Compatibility (EMC) test (see paragraph 6.2.2), but could also be used for the mechanical assembly of large off-line items and the storage of hardware and equipment which require a clean environment.

The SES facility will be used to perform observatory level thermal tests. This area is a contamination controlled area (see paragraph 6.2.7).

The building 10 "big top" clean tent (37 x 18 feet) is a contamination controlled area capable of class 10,000 cleanliness. This area is baselined to be used to perform instrument acceptance testing upon delivery. Also, this area can also be used for mechanical assembly of large items and the storage of hardware and equipment which require a clean environment.

6.1.5 HARDWARE / EQUIPMENT CLEANING FACILITY

Prior to entry into the SCA, the SSDIF, or other clean facility, all hardware, GSE, and equipment, is required to be cleaned. A cleaning facility will be located in the high-bay area of GSFC building 7. In addition, there is a cleaning facility adjacent to the SSDIF in GSFC building #29. Details of these cleaning requirements are addressed in the TRMM Clean Area and Personnel Operations Procedure, document TRMM-724-109.

6.1.6 RCS PTM INSTALLATION AREA

Once the spacecraft mechanical structure has been assembled, tested, and delivered, the RCS PTM will be installed. This activity involves mounting the spacecraft mechanical structure onto the PTM Installation Stand and inserting the RCS PTM up into the structure from below, where it will be bolted into place. It is envisioned that the PTM Installation Stand will be bolted to the floor thus providing a more stable fixture. The RCS PTM installation will be performed in the high-bay area of building 29. The area required for the RCS PTM installation is approximately 20 X 30 feet.

6.1.7 INITIAL SPACECRAFT CLEANING AREAS

Once the spacecraft mechanical structure has been delivered and the RCS PTM installation has been completed, the spacecraft will undergo a "rough" cleaning. This "rough" spacecraft cleaning will be performed in the building 29 high-bay area. Upon completion, the spacecraft will be moved into the building 7 SCA where the RCS installation and mechanical integration will be performed.

After the RCS installation and mechanical integration is complete and once the RCS pressure test has been completed, the spacecraft will be moved into the SCA and undergo its initial cleaning (see paragraphs 6.1.8 and 6.1.9).

6.1.8 RCS INSTALLATION AND MECHANICAL INTEGRATION AREA

The building 7 SCA is baselined to be used as the RCS installation and mechanical integration area. The intent is to perform this activity in a clean environment. Before entry into this area, the spacecraft should have received a "rough" cleaning (see paragraph 6.1.7).

6.1.9 RCS PRESSURE TEST AREA

Once the installation and the mechanical integration of the RCS has been completed, the RCS will be pressure tested checking for leaks. This will be performed in the High Capacity Centrifuge (HCC) rotunda in building 15.

6.1.10 STORAGE AREAS

Most storage requirements can be accommodated in either the I&T operations room, the high-bay work area, or if a clean environment is required, in the SCA, SSDIF, or the SCA RF shield room. (Generally, items stored in the SCA, the SSDIF, or the SCA RF shield room should be items which are used periodically for testing and/or assembly since this space is limited and it is a contamination controlled area). Other storage areas may be used as they become available and are required. It is planned to have storage cabinets available in such places as the I&T operations room, the SCA/SSDIF, and the high-bay work area.

6.1.10.1 BONDED STORAGE AREA

A bonded storage area will be provided by the TRMM Project. Bonded storage is a secure controlled area used for temporary storage. The location of this area will be GSFC building 7, room 15/15A. The TRMM bonded storage area will be under the control of the FAM and the TRMM CMO.

6.2 ENVIRONMENTAL TEST FACILITIES

All environmental testing will be performed in the GSFC building 7/10/15/29 complex. The overall management of these facilities is the responsibility of GSFC Code 750 personnel. The facilities are normally operated by an in-house support service contractor.

An exception to this is the Compatibility Test Van (CTV). It will located about 300 feet north of building 29, and is the responsibility of GSFC Code 515.

A brief synopsis of these facilities is provided in this document as a convenience to the reader only. Details of these facilities, the schedule of activities, and test specifications are included in the TRMM Verification Plan, TRMM-750-113. Also, see the TRMM Project Schedule Baseline Document, document TRMM-490-165, for the schedule dates for various environmental tests.

Environmental Test and Facilities include:

- a. Mass properties
- * b. EMI/EMC
- c. Optical Alignment
- * d. Vibration
- * e. Acoustics and Pyrotechnic Mechanical Shock
- * f. Magnetics
- * g. Thermal Balance / Thermal Vacuum
- * h. Deployment Test Area
- i. Compatibility Test Van
- * J. RCS Leak and Calibration Test

* indicates tests which require a locally adjacent area for the placement of the umbilical console and associated EGSE, and communications and control cables to the TRMM I&T operations room

6.2.1 MASS PROPERTIES

Mass properties including weight, Center of Gravity (CG), and Moment of Inertia (MOI), will be performed in the SSDIF. The weight measurement will be made using a load cell between the overhead crane and the observatory. CG and MOI will be determined using the Mass Properties Measurement Facility (MPMF), which is a totally portable facility, capable of being used in a clean facility.

6.2.2 EMI/EMC

All spacecraft/observatory level TRMM EMI/EMC testing will be performed in the large EMI facility (shield room) located on the northwest side of building 7. The EMI facility is directly adjacent to the SCA with its entrance doors located within the SCA on the downstream end. The EMI facility is a class 10,000 clean room area. The volume of the EMI facility is approximately 35 (width) x 63 (length) x 20 (height) feet.

During EMI/EMC testing, the umbilical console and associated EGSE will be located near the south side entrance door into the SCA, where filtered shield room electrical penetrations into the EMI/EMC facility are located. The EMI/EMC facility may also be used as a clean area for mechanical assembly and checkout area for large items such as solar arrays. It is envisioned to have a similar use for the TRMM Project.

6.2.3 OPTICAL ALIGNMENT

Mechanical alignment will be verified by theodolite measurements of relative orientations of alignment cubes. Mechanical alignments will be performed in the SCA or SSDIF. (In general, once an instrument has been mechanically integrated it will be mechanically aligned. Alignment required by spacecraft subsystems (ACS and RCS) will be performed at convenient times during the ACS nd RCS integration activity).

(Due to the size and weight of the TRMM Observatory, all mechanical alignments must be performed while the observatory is in the vertical position).

6.2.4 VIBRATION

The vibration tests will be performed on the 30K vibration table (shaker) located on the ground level of building 7, test cell room 40. X, Y, and Z axis vibration tests will be performed. The actual vibration levels will be provided by the TRMM Structural Subsystem Lead Engineer. These levels were developed by analysis by the TRMM Structural Team and approved by the NASDA H-II Rocket Team.

The umbilical console and associated EGSE will be required to be located just outside of the vibration facility. In addition communication lines to the TRMM I&T operations room will be required for this test.

6.2.5 ACOUSTICS AND PYROTECHNIC MECHANICAL SHOCK

The acoustic tests will be performed in the acoustic test chamber located on the ground level of building 10, room 023. This facility has a 10 kilowatt noise generation capability.

The pyrotechnic mechanical shock test will also be performed in the acoustic test chamber. This is done for convenience since the observatory will already be located in this facility.

The umbilical console and associated EGSE will be required to be located just outside of the acoustic facility. In addition communication lines to the TRMM I&T operations room will be required for this test.

6.2.6 MAGNETICS

Magnetic survey test will be performed in the SSDIF with use of portable magnetic measuring devices.

6.2.7 THERMAL BALANCE / THERMAL VACUUM

Thermal balance and thermal vacuum testing will be performed in the SES located in building 10, which is connected to the east end of building 7. The interior of the SES is approximately 17 x 40 feet. The thermal environment will be controlled by flooding interior shrouds with gaseous (+75 to -90 degress celsius) or liquid nitrogen (-180 degress celsius). The vacuum system is cryopump (to maintain an oil free environment). The SES is maintained as a clean environment (class 10,000), therefore, clean room garments and practices are required. Access to the SES is located on the ground floor.

The umbilical console and associated EGSE will be required to be located just outside of the SES, on the north side of the main floor, as near as possible to the chamber penetration feed through connector plates. In addition communication lines to the TRMM I&T operations room will be required for this test.

6.2.8 DEPLOYMENT TEST AREA

The deployment test area will be used for a full deployment test of the HGA, the TMI instrument, and the solar array wings. This area will be the large area designated for TRMM in the SSDIF (see paragraph 6.1.4.2), which will accommodate all of the required MGSE to perform these tests. A source of clean pressurized air of approximately 100 pounds per square inch (psi) will be required in this area.

The umbilical console and associated EGSE will be required to be located adjacent to the deployment test area. In addition communication lines to the TRMM I&T operations room will be required for these tests. (However, since the SSDIF will be used for other TRMM I&T activities, these requirements should have already been met).

6.2.9 COMPATIBILITY TEST VAN

The CTV will be utilized for two primary purposes: (1) to perform compatability testing for the transponders on the TRMM Observatory, and (2) to provide RF up and down transmission links to the TDRSS during mission simulation end-to-end testing. During compatability testing for the transponders, the CTV will accomplish RF spectrum, sensitivity, and mode verification thus verifying the correct operation of the transponders. The CTV also has Space Network (SN) RF link capabilities.

The CTV is a large trailer with equipment specifically designed, with experienced operators trained for these purposes. The CTV and its operation is the responsibility of GSFC Code 515.

Its planned location is on the north side of building 29. A concrete pad, AC electrical services, and concrete duct banks for RF, signal, and voice communications cabling from/to building 29 will be available.

A patch panel will be available in building 29, located in room 150 for interfacing the TRMM Observatory and I&T Operations Room located inside the GSFC building 7/10/15/29 complex to the CTV outside.

6.2.10 RCS LEAK AND CALIBRATION TEST

A RCS leak and calibration test will be performed to verify the integrity of the RCS system at flight pressures and to calibrate the pressure transducers and pressure regulators. This test will be performed in the SSDIF.

6.3 I&T OPERATIONS ROOM AND OFFICE SPACE

For the TRMM Program various personnel work areas are required. These include the I&T operations room and offices.

6.3.1 I&T OPERATIONS ROOM

The TRMM I&T Operations Room will be located in building 7, room 158. It will house the SGSE, the IGSEs, and various EGSE. The I&T operations room will be the focal point of nearly all (if not all) TRMM I&T activities involving spacecraft or observatory powered up operations. From here the spacecraft test conductors will operate and control the spacecraft and the instrument test conductors will operate and control the instruments throughout the TRMM I&T effort here at the GSFC.

The I&T operations room will be divided into six areas: a large area for spacecraft operational support items and personnel, and smaller equally sized areas for operational support items and personnel for each of the five instruments onboard the TRMM Observatory. The large section of the I&T operations room designated for the spacecraft will be used to house the SGSE, various EGSE, and work areas for the spacecraft test conductors and subsystem engineers. Each instrument designated area will be used to house the IGSE for that instrument and a work area for the instrument test team.

The SGSE racks used for front end data processing, data storage, commanding, etc., along with various rack mounted EGSE will be located in an accessible corner of the area designated for the spacecraft. Also, in this area the seven SGSE workstations will be set up in a workable configuration from which the spacecraft test conductors will operate the observatory and the subsystem engineers will monitor their subsystems performance. The spacecraft test conductors will control how this area is configured, and what personnel and GSE is allowed in this area. Also, the spacecraft test conductors will have control of this area and ultimate control of the entire I&T operations room. Any conflicts or major problems will be resolved by the TRMM I&T Manager.

Each area designated for each instrument will contain the IGSE for the respective instrument along with a operational work area for the instrument test team. The instrument test team will control how their area is configured, and what personnel and GSE is allowed in this area. The instrument test team will have control over the area for their instrument as long it is agreeable with the spacecraft test conductors and the TRMM I&T Manager.

The I&T operations room will have raised flooring under which will be electrical outlets to accommodate the required electrical services. Also, (where possible) all cabling between GSE and for communications will be located under the raised floor. (See section 6.4 and Appendix B for more information on required electrical services. See section 6.4 for more information on cabling for GSE and communications).

See Figure 6-6 for the TRMM I&T Operation Room Preliminary Layout, building 7, room 158.

6.3.2 OFFICE SPACE

Office space within the GSFC building 7/10/15/29 complex will be required to house various personnel on the TRMM I&T team. These personnel include the TRMM I&T Manager, spacecraft test conductors, instrument personnel, spacecraft subsystem personnel, technical support personnel, and various personnel. This will allow key I&T personnel to be near the spacecraft and more readily available. The baseline area for this office space is GSFC building 29, room 360.

6.4 POWER AND COMMUNICATIONS REQUIREMENTS

AC power and communications lines will be required in the various TRMM I&T locations and in the TRMM I&T operations room. This involves "quiet" AC power services, spacecraft hardline command and data interfaces, LAN interfaces, GSE interfaces, voice communications links, and a variety of other requirements. The intent of this section is to identify these requirements. These requirements are being worked by GSFC Code 733 personnel.

6.4.1 AC POWER REQUIREMENTS

The installation of various AC electrical services are required in the various test areas. These AC electrical services will be designated as "quiet", and have "quiet ground" plates installed in the immediate vicinity of the power outlets.

6.4.1.1 UMBILICAL CONSOLE

The umbilical console and associated EGSE will require Hubbell twist lock compatible receptacles at the various test sites for both a 3-phase, 208 volts, 60 amperes service and a 1-phase, 115 volt, 30 amperes service. These two services are for the EGSE UPS. In addition, a number of standard 115 volt AC 3-prong outlets. (See Appendix B for list of EGSE and its power requirements).

The umbilical console and associated EGSE and umbilical cabling will move with the spacecraft to the various test locations. Therefore, these connections are not only required near the SCA or SSDIF, but also are required near the EMI/EMC, the vibration, the acoustic, and the thermal balance / thermal vacuum test facilities.

6.4.1.2 I&T OPERATIONS ROOM

The SGSE front end computer system will require 1-phase, 115 volt, 15 amperes. The RF test rack will require 1-phase, 115 volt, 20 amperes. Other equipment in the I&T operations room such as the baseband equipment rack, the SGSE workstations and printers, the IGSEs, and other miscellaneous electrical equipment will be serviced by standard 115 volt AC 3-prong outlets located under the raised floor. An adequate number of outlets will be available. (See Appendix B for power requirements for this equipment).

6.4.2 UNINTERRUPTABLE POWER SUPPLY

To avoid loss of AC power to certain EGSE elements during critical test periods it will be necessary to provide an Uninterruptable Power Supply (UPS) system. The following EGSE elements, at a minimum, are to be connected to the UPS:

* umbilical console
  - TIMACC
  - spacecraft umbilical power supply,
  - command and telemetry interface circuits,
  - panel meter readouts,
  - stripchart recorder
  - solar array simulator
  - battery simulator

* I&T operations room
  - analog recorder
  - manual command generator
  - others TBD

The UPS will be provided along with the EGSE by GSFC Code 733. GSFC Code 733 will be responsible for its implementation at GSFC.

6.4.3 INTRA-BUILDING CABLING

Due to the nature of the GSFC building 7/10/15/29 physical layout, all hardware interfaces for command, telemetry, RF, voice, etc., will require the use of intra-building cabling. This may be in the form of twisted shielded pair, multiconductor, or various types of coaxial cabling.

Examples of this requirement would include the following:

- Umbilical console (to spacecraft) to SGSE hardline command and telemetry links
- SGSE front end computers to workstations
- baseband equipment to umbilical console and SGSE front end
- voice communications
- RF command and telemetry links
- closed circuit television
- NASCOM interfaces
- others as needed

The GSFC building 7/10/15/29 complex already has an ample number of these cables installed, and, in general, are easily patchable to connect the various areas. There have also been many dedicated lines installed by past programs. GSFC Code 733 will be responsible for defining the cabling requirements for the TRMM program. All subsystem and instrument personnel requiring any special services should inform the TRMM I&T Manager of their requirements. Requests are forwarded to a GSFC Code 750 contract monitor. A TAR (see Figure 6-7) is then initiated to have the work performed by the in-house contractor.

6.4.4 VOICE COMMUNICATIONS

The voice communications for TRMM I&T will be comprised of two different systems; an intra-building communications system for general I&T activities and an inter-building communications system for I&T activities involving the MOC.

For I&T activities within the GSFC building 7/10/15/29 complex, the presently installed MITOC system will be used. Installation of these units, and associated cabling to the SGSE, each IGSE, and each I&T location within the GSFC building 7/10/15/29 complex will be required. These units are 3.5 inches in height, rack mountable, and have multi-channel capability.

When testing involves the GSFC Code 500 elements, including the MOC and ground network stations, the NASA-SCAMA "green phones" with "squawk-boxes" will be located in the SGSE area of the TRMM I&T operations room. This is a separate network from the MITOC system; there is no electrical connection between them.

6.4.5 MISSION OPERATIONS

At certain points in the I&T schedule, the SGSE will be configured to allow the MOC to perform observatory testing. The NASCOM (GSFC Code 500) data and voice link is utilized for these tests involving the missions operations etwork. Intra-building cabling provides the signal path for the NASCOM GSFC Code 500) link from its point of entry into building 7 to the SGSE located in the I&T operations room. NASCOM provides the receiver/drivers for the baseband command and telemetry, and voice communications interfaces in the I&T operations room. They also provide the "green phones" with "squawk boxes" for voice communications. Requests for these services are forwarded to the project Mission Operations Manager (MOM).

6.4.6 TDRSS RF COMMUNICATIONS

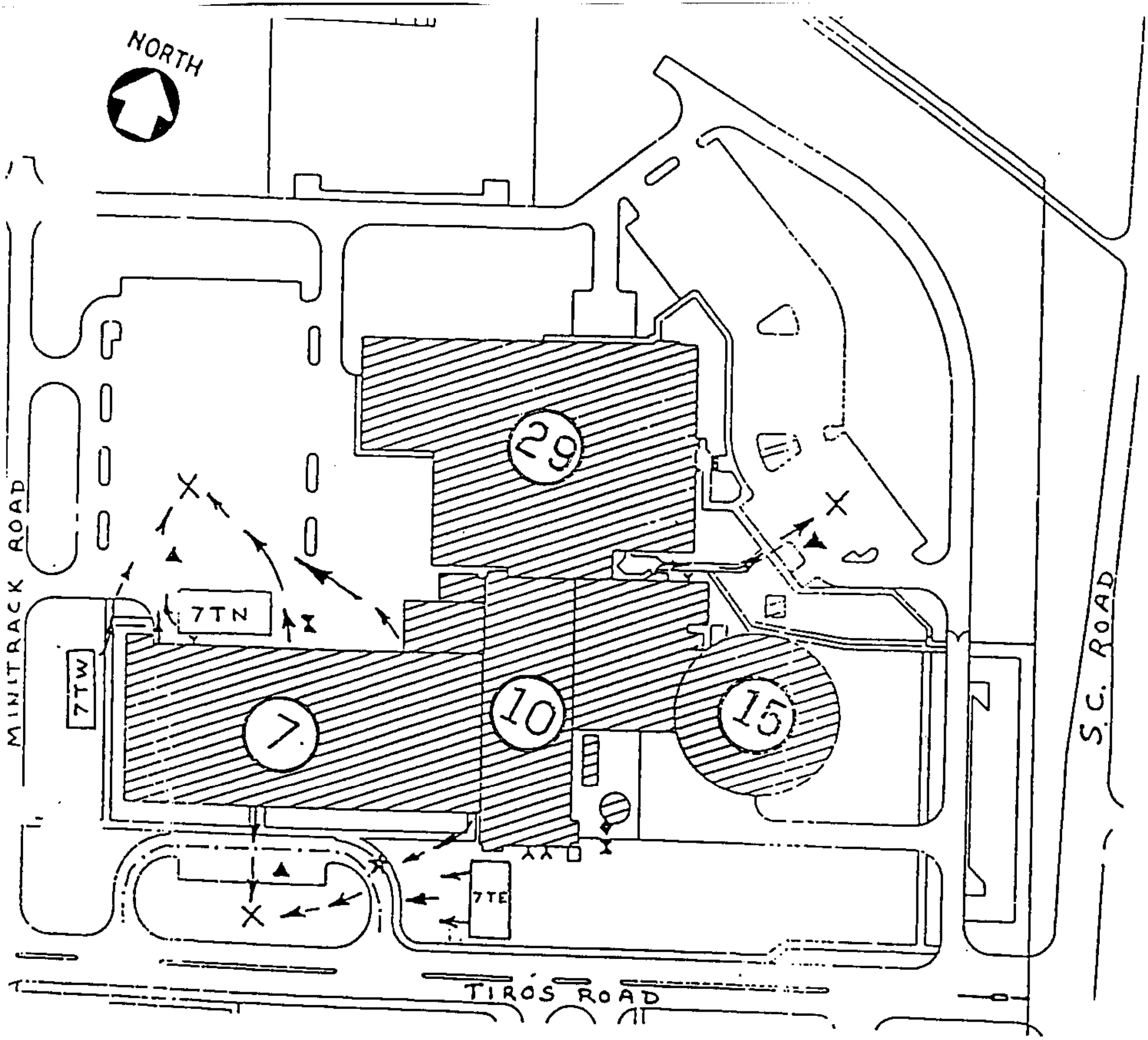
There will be a requirement during network test activities to perform RF link and compatibility testing with a TDRSS satellite. This will require the connection of the spacecraft transponders to an RF transmitting and receiving dish antenna located on the CTV. Low-loss RF cabling will be required from the observatory to a patch panel located in building 29 which interfaces with the CTV (see paragraph 6.2.9). The observatory will either be located in the SCA, the SSDIF, or SES for this testing. GSFC Codes 515 and 737 will have the joint responsibility to supply the dish antenna, any required RF connectors, RF adaptors, etc., and the RF cabling between the building 29 patch panel and the observatory.

6.4.7 RF COMMUNICATIONS

The GSFC building 7/10/15/29 complex has a large number of low-loss coaxial cables installed between the various test locations. Patch panels are available in various locations to connect the required signals.

6.4.8 CLOSED CIRCUIT TELEVISION

I&T activities at various locations (especially the SCA and the SSDIF) will be monitored with a Closed Circuit Television (CCTV) system. This will provide the spacecraft test conductors with a means of viewing the activities on and around the observatory, and to observe the motion of mechanisms and sensors during testing. The control unit will be located in the TRMM I&T operations room. GSFC Code 750 is responsible for the implementation.



★ Emergency Command Post Vehicle
▲ Warden With Radio
Evacuation Route
Fire Lane
Y Stand Pipe
LN2 Hazard Area
◆ GN2 Hazard area
X PERSONNEL ASSEMBLY AREA

Fi   e 6-1 INTEGRATION AND ENVIRONMENTAL TEST FACILITIES AT GSFC BUILDINGS 7/10/15/29

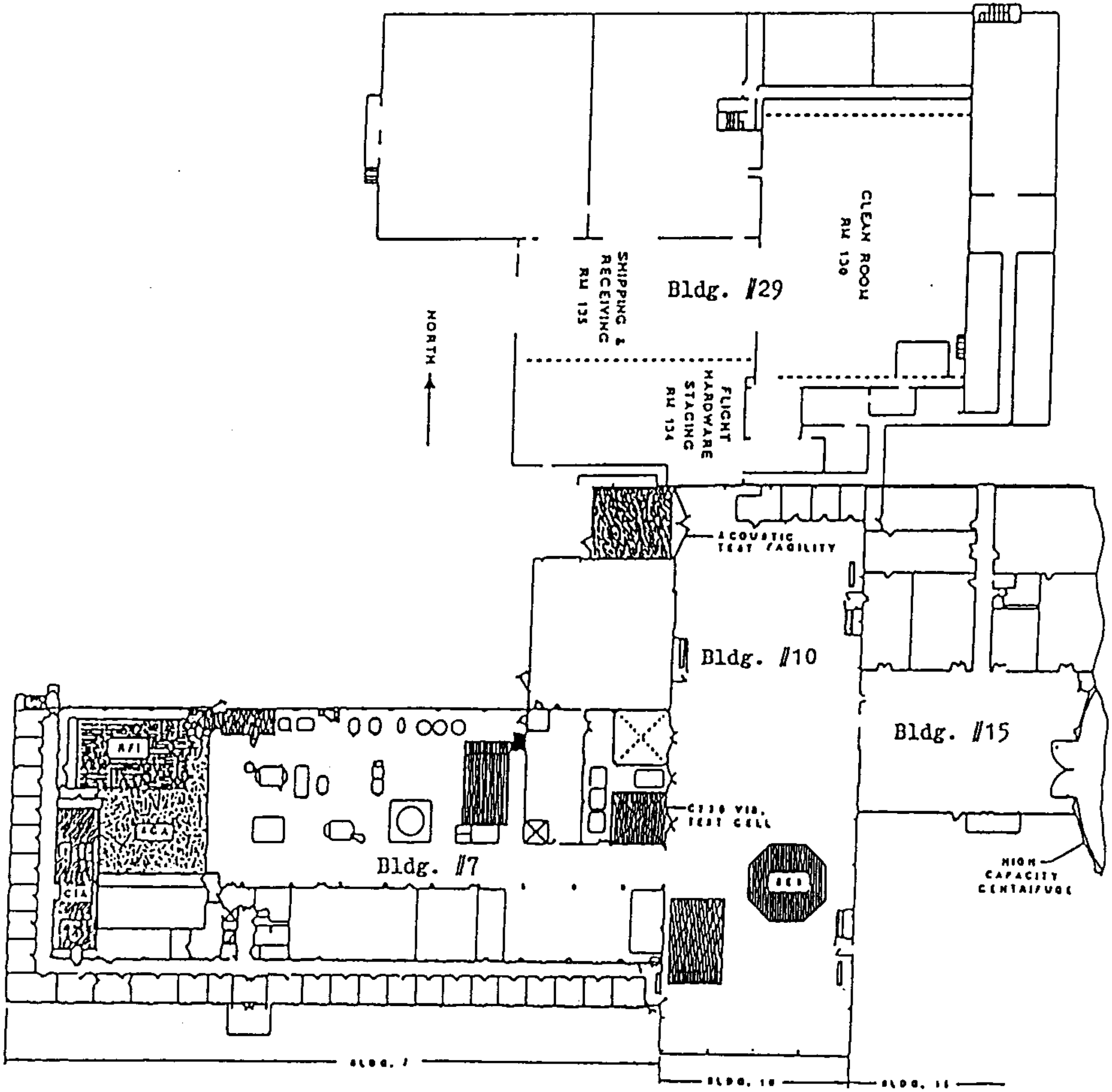


Figure 6-2 GSFC BU GS 7/10/15/29 LAYOUT

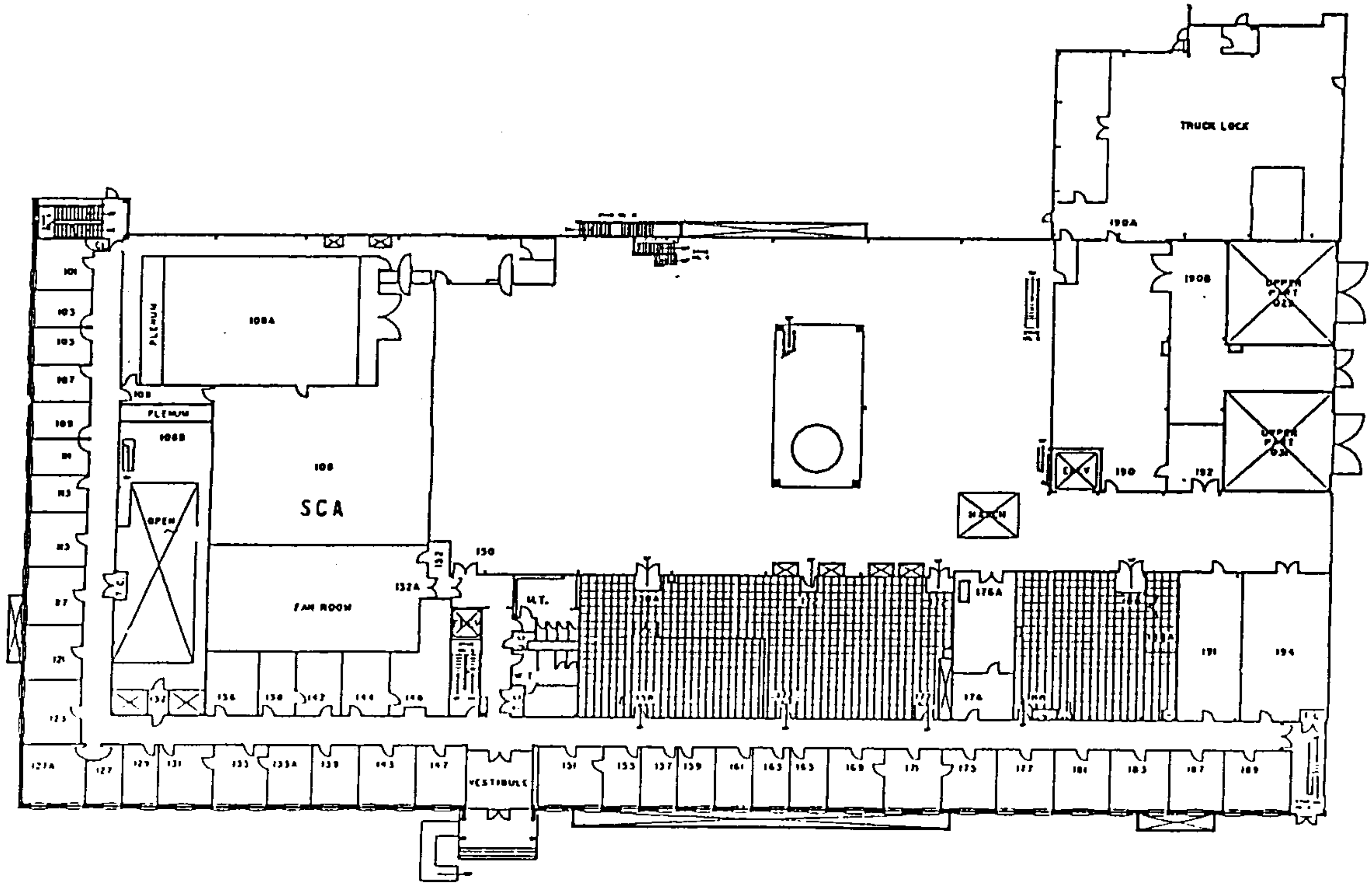


Figure 6-3 C BUILDING 7 LAYOUT

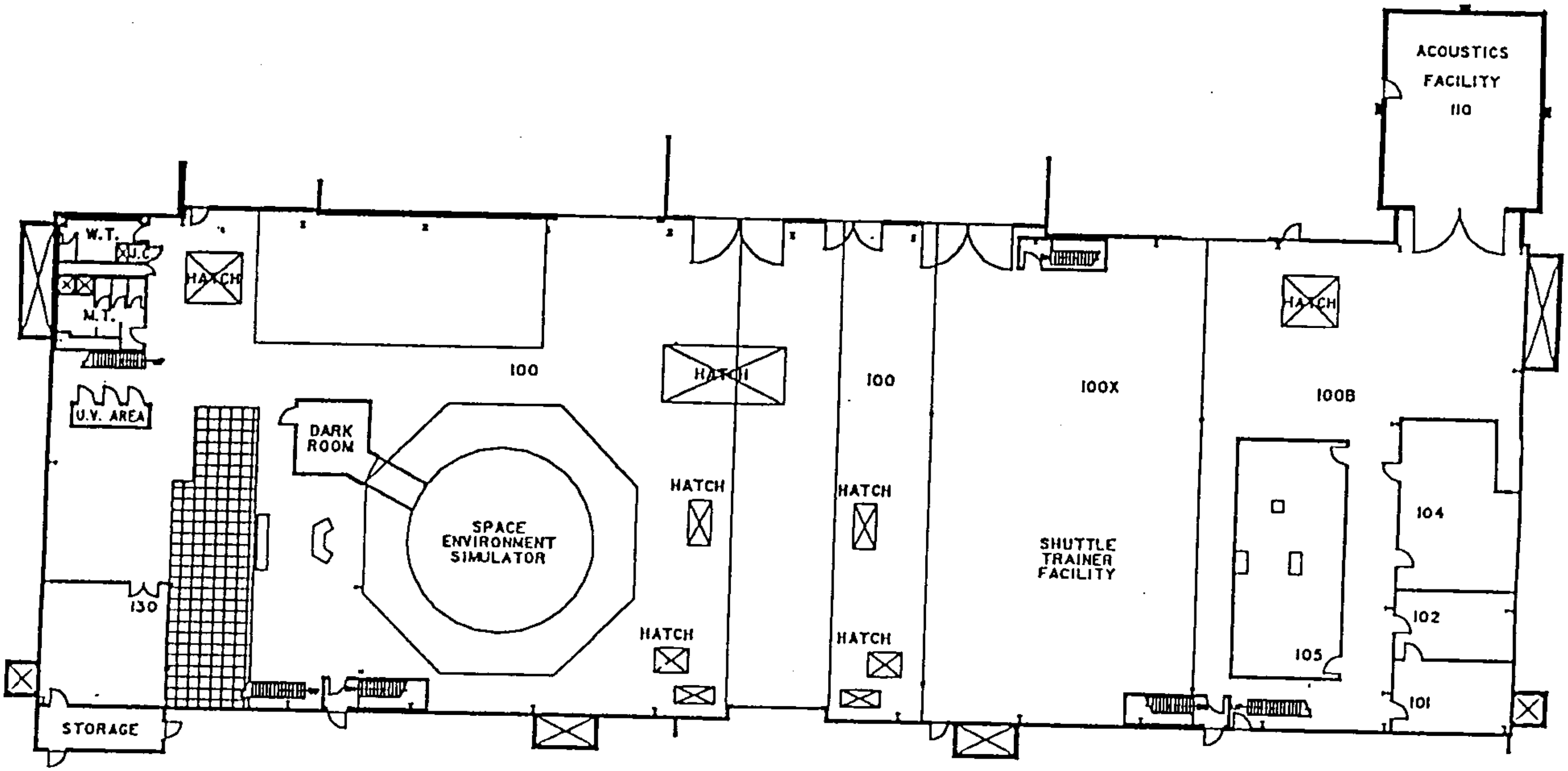


Figure 6-4 GSFC BUILDING 10 LAYOUT

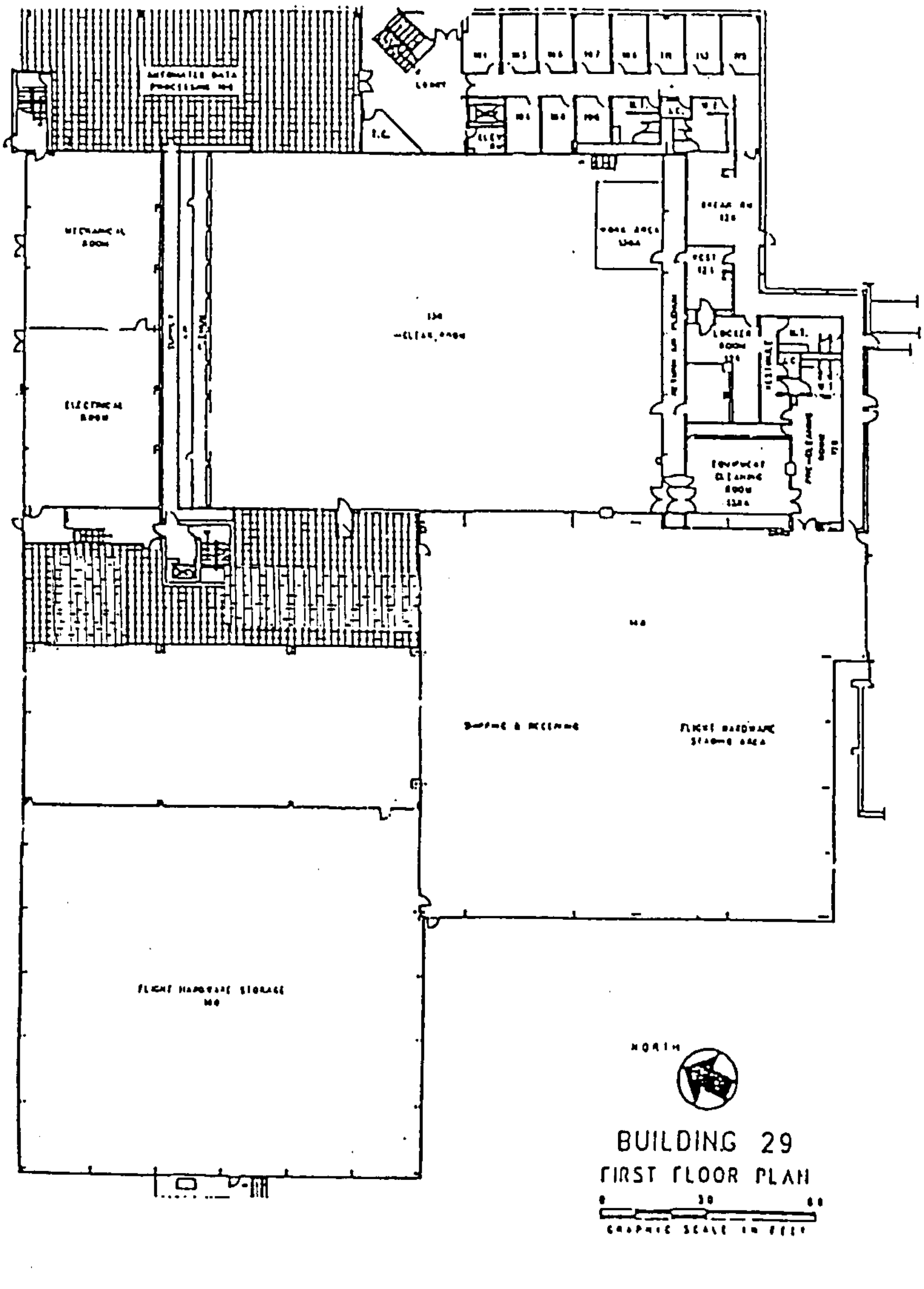


Figure 6-5 GSFC BUILDING 29 LAYOUT

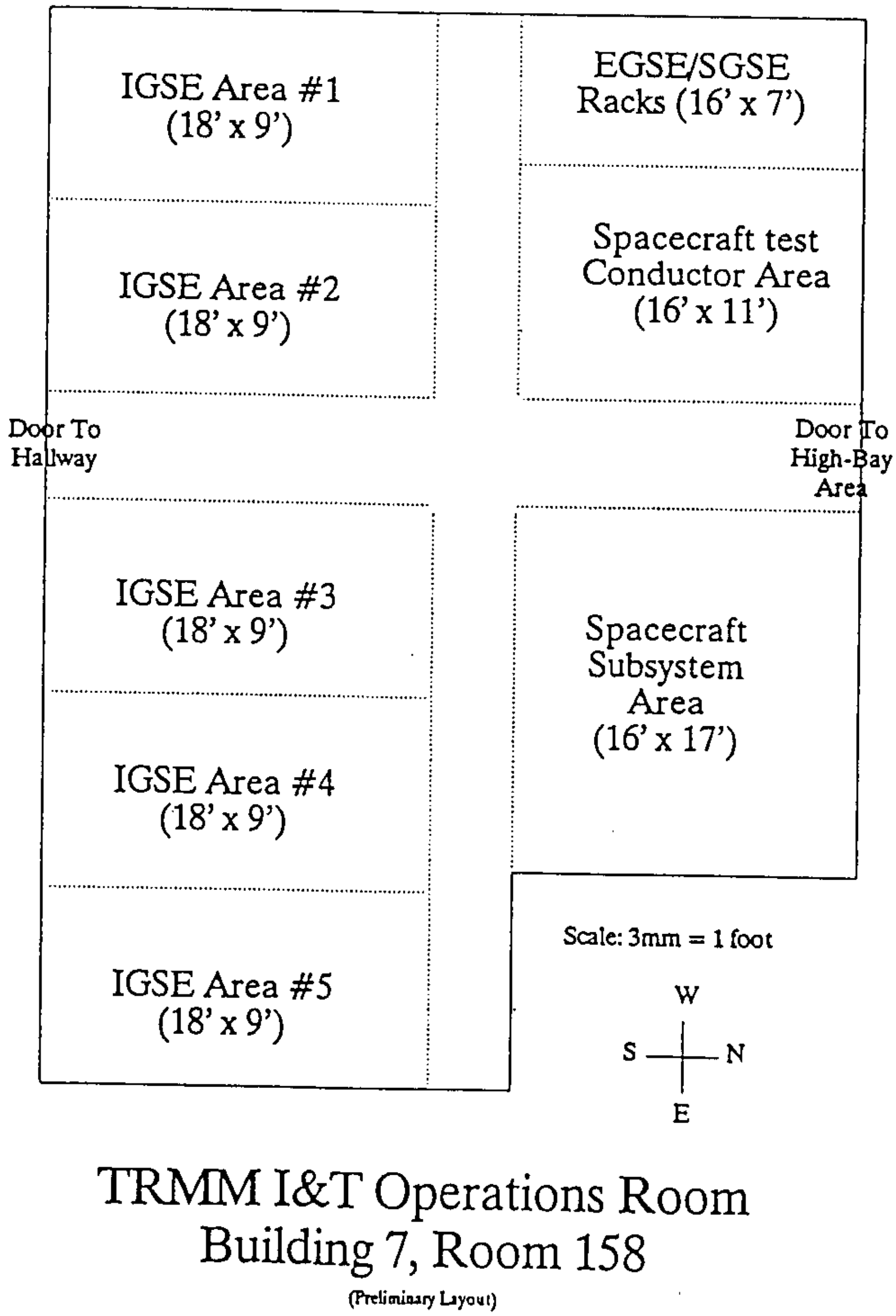


Figure 6-6 TRMM I&T OPERATIONS ROOM PRELIMINARY LAYOUT

GODDARD SPACE FLIGHT CENTER
ENGINEERING SERVICES DIVISION
CODE 750

TASK ACTION REQUEST

39. HAZARDS

40. TEST SPECIFICATION

41. TEST PLAN/OTHER

42. CLEANLINESS REQUIREMENTS

43. NOTES:

Figure 6-7 TASK ACTION REQUEST

7.0 INTEGRATION AND FUNCTIONAL TEST SUPPORT REQUIREMENTS

The purpose of this section is to address those items which support the integration and functional test requirements during the TRMM Observatory I&T, verification, shipment, and pre-launch activities. These items can generally be broken down into two categories; GSE and Test Procedures.

The term GSE includes all non-flight equipment required to support the TRMM Observatory I&T, verification, shipment, and pre-launch activities (see Figure 7-1). GSE can either be electrical or mechanical in nature. For this document, GSE will be broken down into the following categories:

* GSE Electrical In Nature
  - EGSE
  - SGSE
  - IGSE
  - BGSE
* GSE Mechanical In Nature
  - MGSE

The combination of the EGSE, SGSE, IGSEs, BGSE (sometimes collectively referred to as the observatory EGSE), and MSGE will be capable of supporting all phases of I&T, verification, shipment and pre-launch activities for the TRMM Observatory. This section provides an overview of the required elements for each type of GSE.

Test procedures include written and planned actions to be performed to integrate, test, validate, and operate the TRMM flight hardware and observatory. This section provides requirements and guidelines for the generation of these required test procedures.

7.1 ELECTRICAL GROUND SUPPORT EQUIPMENT

The Electrical Ground Support Equipment (EGSE) to support observatory integration and testing will include the following elements:

* Spacecraft Umbilical Console (comprised of two separate racks)
* Analog Tape Recorder
* Stripchart Recorder
* Baseband Equipment Console
* Radio Frequency GSE
* "Standard" Spacecraft Interface Simulator
* NASCOM Command And Data Handling Interface
* Generic Test Equipment
* Special Purpose Test Equipment
  - Breakout Boxes
  - Portable Pyrotechnics Circuit Test Unit
* Uninterruptable Power Supply

This section provides an overview of the EGSE elements, where and how the various EGSE elements are to be implemented, and who is responsible for the various EGSE elements. In general, not only will all EGSE elements be required to support the TRMM I&T activities at the GSFC, but they will be required to support pre-launch activities at the TnSC. (See Figure 7-2 for a block diagram of the EGSE interfaces during I&T).

7.1.1 SPACECRAFT UMBILICAL POWER CONTROL AND MONITORING CONSOLE

An umbilical console is required to perform all of the typical spacecraft power control and monitoring, and hardline command/telemetry interface functions. (See Figure 7-3).

It is a combination of electrical and electronic equipment specially developed for the TRMM Observatory, and commercially available electronic equipment to provide the required functions.

GSFC Code 733 is responsible for providing the umbilical console and related EGSE, except for the solar array simulator provided by GSFC Code 734. The umbilical console and related EGSE will be located as close as reasonably possible to the observatory throughout the I&T activities at the GSFC and throughout the pre-launch activities at the TnSC (see section 6.0 and 11.0 for the respective centers). The umbilical console and related EGSE will be operated and monitored by the spacecraft electrical technicians.

The following are features and elements of the umbilical console and related EGSE:

a. Solar Array Simulator (supplied by GSFC Code 734)
   - Capable of delivering 3000 watts of power (43 amperes at 70 volts DC) (however this much power is not required)
   - Light Emitting Diode (LED) digital readout meters
   - Simulates solar array input to SPRU

b. Umbilical Console Auxiliary Power Supply
   - Capable of delivering 1600 watts of power (16 amperes at 100 volts DC) to SPRU input
   - Backup for solar array simulator

c. Solar Array Simulator Power Bus Monitoring
   - LED digital readout meters
   - Solar array bus voltage monitor at spacecraft
   - solar array bus current monitor at spacecraft

d. Umbilical Console Auxiliary Power Supply
   - LED digital readout meters
   - Auxiliary power bus voltage monitor at spacecraft
   - Auxiliary power bus current monitor at spacecraft

e. Power Supply Electronics (PSE) Voltage/Current Monitor Panel
   - LED digital readout meters
   - Hardline monitors of various PSE voltages and currents
   - Usually the same as telemetry monitors

f. Battery Online Control and Monitoring Panel
   - Panel connect/disconnect switch and lamp indicators
   - Panel voltage and current monitors

g. Battery Trickle Charge Panel
   - Panel dedicated to provide trickle charge to spacecraft batteries
   - Normally supplied when spacecraft is powered off
   - Trickle charge current to each spacecraft battery is 1 ampere (at 33 volts DC)

h. Umbilical Console Interface Cabling with Spacecraft
   - Umbilical console to spacecraft for power
   - Umbilical console to spacecraft for PSE monitors, commands, and telemetry
   - Umbilical console to spacecraft for battery trickle charging

i. Umbilical Console Interface Cabling with I&T Operations Room
   - Intra-building cable interfaces
   - Command and telemetry interfaces

j. Critical Power Bus Monitors/Alarms
   - Provide Audible/visual alarms with adjustable upper and lower limits for monitoring critical functions, such as:
     - Battery voltages and current
     - Solar Array Simulator bus voltage and current
     - Essential bus voltage and current

k. Runtime Meters
   - Hours accumulation meter for when power is applied to the spacecraft (total measure of time spacecraft is powered)

l. Automatic Power Disconnects
   - Solar array relay drops out when the solar array bus to the spacecraft reaches an overvoltage condition of TBD volts
     - If umbilical direct current power supply is used
       - Over voltage and current crowbar
       - Solar array bus disconnected

m. Spacecraft Command Decoders Hardline Commanding Control
   - Panel for manual enable/disable and status for hardline commanding

n. Command and Telemetry Patch Panel
   - Patch panel in the local vicinity of the umbilical console for patching of uplink commands and downlink telemetry

o. Ancillary Equipment at Umbilical Console
   - Stripchart recorder for realtime voltage and current monitoring
     - Buffering may be required to prevent loading of PSE status monitors

p. Flashing Beacon
   - Installed portable beacon on the topside of the main console to alert personnel in the area when the solar array bus is enabled

7.1.1.1 ANALOG TAPE RECORDER

An analog tape recorder will be included as part of the EGSE. The analog tape recorder will be used as much as possible to record all of the "raw" spacecraft telemetry. It will provide an archive and backup service if there is a failure within the SGSE. The analog tape recorder will have a high bandwidth, not only capable of recording the low rate "I" channel telemetry, but also the high rate "Q" channel telemetry, simultaneously.

GSFC Code 733 is responsible for providing the analog tape recorder. It is to be located in the TRMM I&T operations room throughout the I&T activities at the GSFC and in #2STA (Spacecraft Testing and Assembly building #2) throughout the pre-launch activities at the TnSC. The analog tape recorder will be operated by the spacecraft test conductors. Analog tapes will be provided by GSFC Code 733.

7.1.1.2 STRIPCHART RECORDER

A stripchart recorder will be included as part of the EGSE. It will be connected to the umbilical console directly recording many of the spacecraft voltages and currents displayed on the umbilical console, i.e., bus voltage, essential and non-essential bus currents, battery voltages and currents, etc. It will provide a recorded history of these monitors and will have a "quick" response time showing any "spikes" or "glitches" on any of these busses.

GSFC Code 733 is responsible for providing the stripchart recorder for the umbilical console. As the umbilical console is moved around to various test sites, this stripchart recorder is to remain with it. Along with the umbilical console, this stripchart recorder will be operated by the spacecraft electrical technicians. Stripchart paper/toner for this unit will be provided by GSFC Code 733.

7.1.2 BASEBAND EQUIPMENT CONSOLE

The baseband equipment console will receive data from either the spacecraft directly when in the hardline mode, or data from the RFTR when in the RF mode. It will then provide all necessary decoding before the data is delivered to the SGSE front end for telemetry ingest. The baseband equipment console will have two identical telemetry decoding sections; one for "I" channel low rate telemetry data, the other for "Q" channel high rate telemetry data. Also, the baseband equipment console will provide Phase-Shift-Key (PSK) modulation for the command data. The baseband equipment console will be comprised of the following equipment:

- bit synchronizers
- convolutional (Viterbi) decoders
- transfer frame synchronizers
- Reed-Solomon decoders
- patch panel(s)
- PSK modulator

GSFC Code 733 is responsible for providing the baseband equipment console. It is to be located in the TRMM I&T operations room throughout the I&T activities at the GSFC and in #2STA throughout the pre-launch activities at the TnSC. The baseband equipment console will be configured and operated by the spacecraft test conductors.

7.1.3 RADIO FREQUENCY GSE

The Radio Frequency (RF) GSE will consist primarily of a TDRSS second generation transponder compatible RFTR, capable of providing an RF uplink for commands and receiving the downlink telemetry with de-modulated outputs. The RFTR shall not only support TDRSS command and telemetry signals, but shall also support GSTDN/DSN command and telemetry signals. Also included as RF GSE are occasional use items such as spectrum analyzers, RF power meters, RF attenuators and "dummy" RF loads.

GSFC Code 737 is responsible for providing the RFTR. It is to be located in the TRMM I&T operations room throughout the I&T activities at the GSFC and in #2STA throughout the pre-launch activities at the TnSC. The RFTR will generally be configurated and operated by the TRMM RF communications subsystem test team (GSFC Code 737). GSFC Code 737 will provide and operate as needed other RF GSE listed above.

7.1.4 SPACECRAFT INTERFACE SIMULATOR

Each TRMM Instrument developer group will be provided a "standard" spacecraft interface simulator during selected periods of instrument development. The plan is that a total of four will be available to share among the five instruments. Due to the location of the PR Instrument developer, one will be dedicated to the PR Instrument. The other three will be shared between TMI, VIRS, LIS, and CERES. The spacecraft interface simulators will be developed and provided by GSFC Code 733. Its purpose is two-fold:

1. to provide the flight-like spacecraft interface to the instrument, and
2. to provide the SGSE to IGSE interface as will be seen at GSFC.

This plan should minimize the problems and time required to integrate the IGSE to the SGSE and the problems and time required to electrically integrate the instrument to the spacecraft. (For a description of the spacecraft interface simulator(s) see the TRMM Spacecraft Simulator Description Document, document TRMM-733-105, for spacecraft simulator requirements see the TRMM Spacecraft Simulator Requirements Document, document TRMM-733-120, also see the TRMM IGSE To SGSE ICD, document TRMM-733-104 for additional information).

7.1.5 NASCOM COMMAND AND DATA HANDLING EQUIPMENT

A GSFC Code 515 provided Programmable Data Formatter (PDF) will be used during I&T for command and telemetry handling between the MOC and the observatory. It will be comprised of a NASCOM blocker/deblocker, personal computer (for control of set up characteristics for mission operations and data and status printout), patch panel, and NASCOM supplied amplifiers to handle the transfer of command and telemetry data on the NASCOM network.

The PDF is to be located in the TRMM I&T operations room throughout the I&T activities at the GSFC and in #2STA throughout the pre-launch activities at the TnSC. The PDF will generally be configurated and operated by GSFC Code 500 personnel and at times the spacecraft test conductors.

7.1.6 GENERIC TEST EQUIPMENT

Generic test equipment will be provided by the TRMM I&T team (GSFC Code 733). This equipment includes, Digital Multimeters (DMMs), oscilloscopes (with storage capabilities and camera with film), milliohm meter, AC and DC current meters, and loads, jumpers, and bottle plugs for BOBs.

All applicable generic test equipment shall have a valid calibration sticker before use. Typically, the equipment is calibrated on a six month basis. GSFC Code 733 will maintain valid calibration for this equipment.

All subsystem and instrument test teams shall notify the I&T team well in advance (not less than 1 month) of any test equipment required that is not mentioned in this document. This will allow this equipment to be located and calibrated if required.

Generally this test equipment will only be used during integration activities, however, it shall be available throughout the TRMM I&T effort at both GSFC and TnSC.

7.1.7 SPECIAL PURPOSE TEST EQUIPMENT

Special purpose test equipment is test equipment that is provided for a specific purpose or use. It includes, but is not limited to BOBs, a portable pyrotechnics circuit test unit, optical test equipment, and bus monitors. (Generally the same rules and conditions applied to "generic test equipment" in paragraph 7.1.6 apply to special purpose test equipment).

7.1.7.1 BREAKOUT BOXES

Breakout Boxes (BOBs) will be utilized during any electrical signal verification or check involving the spacecraft electric harness, or any inter-box electrical verification. In general, there will be at least two vailable per each connector type on the observatory. Also, the use of BOB adaptor cables will be implemented for some connector types.

These BOBs will be provided by GSFC Code 733. They will be required at both GSFC and TnSC.

7.1.7.2 PORTABLE PYROTECHNICS CIRCUIT TEST UNIT

The portable pyrotechnics circuit test unit will provide a means of verifying the integrity of the pyrotechnic circuits and devices in the spacecraft. The following are its functions:

- Circuit and device resistance test capability (using a Alinco igniter circuit tester or equivalent)
- Capability for oscilloscope monitoring of all circuits, including those associated with SPSDU firing sequence(s)
- Capability of verifying pulse integrity by use of electronic circuitry and display devices (this also provides a visual verification of proper firing sequence)
- Dummy load to test spacecraft firing capability
- Pyrotechnic connectors Arming/Safeing capability
- Capability of connections at the pyrotechnic device connectors for end-to-end firing pulse verification (this may require a smaller subset test unit with similar circuitry)

The portable pyrotechnics circuit test unit will be provided by and operated by GSFC Code 733. It will be required at both GSFC and TnSC.

7.1.7.3 OPTICAL TEST EQUIPMENT

Optical test equipment will be used to test the fiber optic cables and star couplers. This equipment includes the following:

- Optical Time Domain Reflectometer (OTDR)
- Optical power meter
- Optical light sources
- Optical microscopes
- Optical oscilloscope

The optical test equipment will be provided and operated by GSFC Code 733 or/and 735. It will be required at both GSFC and TnSC.

7.1.7.4 BUS MONITORS

The TRMM Observatory contains three separate 1773 data busses. They are commonly referred to as the spacecraft bus, the ACS bus, and the instrument bus. Each bus is redundant, i.e., contains an "A" and a "B" bus for a total of six. A test port will be provided on the spacecraft test panel for each of the six 1773 data busses. This will allow access to each 1773 data bus for the purpose of testing and monitoring the bus with the use of a bus monitor.

The function of the bus monitor is to monitor all communication traffic on the bus, generated by either the Bus Controller (BC) or the Remote Terminals (RTs). The bus monitor itself does not communicate to the BC or to any RT, and does not respond to any BC or RT communications. It is a transparent device to the rest of the devices connected to the 1773 data bus.

At least one bus monitor will be provided by GSFC code 733 and designated to support the TRMM I&T effort. This bus monitor will have the capability of monitoring both the "A" and "B" bus of any of the three busses simultaneously. The bus monitor can easily be moved and configured to monitor any of the three 1773 data busses as needed. The bus monitor itself is configured to monitor 1553B busses. (The 1773 bus is a fiber optic version of the 1553B bus, however, the communications protocol for both are identical). A "gateway" will also be provided with the bus monitor to convert the 1773 bus optical signals from the spacecraft to the 1553B bus electrical signals required by the bus monitor.

7.1.8 UNINTERRUPTABLE POWER SUPPLY

An Uninterruptable Power Supply (UPS) will be required as part of the EGSE. (See paragraph 6.4.2 for its purpose and use).

7.1.9 EGSE PRECAUTIONS

To avoid accidental power supply power off, all critical power supply On/Off switches shall be covered with a spring loaded cover. To avoid accidental shorting from external objects of internal power busses, all in-house manufactured or commercial equipment shall have protective covers.

7.1.10 EGSE DELIVERY

The plan is for the key EGSE elements be delivered to the appropriate areas and configured and checkout for use while the electrical harness is being integrated onto the spacecraft (see TRMM Project Schedule Baseline Document, document TRMM-490-165). The key EGSE include the umbilical console and associated EGSE, the baseband equipment console, the RFTR, the PDF, most generic and special purpose test equipment, and the UPS. Other EGSE items should be available as needed. The EGSE will be configured for use by GSFC Code 733.

7.1.11 EGSE SPACE AND POWER REQUIREMENTS

For space and power requirements of all EGSE, see Appendix B. (Note that this ppendix gives the size of each EGSE item, a reasonable amount of additional ace is required for access and operation).

7.2 SPACECRAFT GROUND SUPPORT EQUIPMENT

The Spacecraft Ground Support Equipment (SGSE), commonly referred to as the spacecraft I&T computer system, is the Automated Data Processing (ADP) equipment used to control and operate the spacecraft throughout I&T.

This section provides an overview of the SGSE features. The SGSE, with the spacecraft test conductors orchestrating, will be the focal controlling point for spacecraft and observatory powered-up operations.

Details for implementation and operation are addressed in the TRMM I&T Ground System Requirements Document, document TRMM-733-095.

The SGSE software will be developed, verified, and maintained by GSFC Code 733. The SGSE hardware will be provided and maintained by GSFC Code 733.

The SGSE will contain two Spacecraft Ground Data Distribution Units (SGDDU). Each will contain a VME based Motorola 68000 series computer. The combination will perform telemetry ingest, telemetry packet extraction and distribution, command link management, and online/offline history data ingest and distribution.

The online history system will provide near realtime history data ingest, and retrieval.

The SGSE will contain seven workstations for TRMM. These will be utilized by the spacecraft test conductors for data base, page display, and STOL procedure development, and for operating, controlling, and monitoring the spacecraft during powered operations. Each workstation will contain the STOL interactive test software. The main hardware element of these workstations will be an IBM RS/6000, model 320H computer. The Transportable Payload Operations Control Center (TPOCC) version of STOL will be utilized as the baseline for the TRMM I&T STOL. Enhancements unique to I&T testing might be required.

The SGSE will contain a Local Area Network (LAN) for information transfers between the SGDDUs, workstations, and the IGSEs, will be ThinNet ethernet.

Throughout all TRMM I&T activities at the GSFC, the SGSE will be located in the TRMM I&T operations room, building 7, room 158. However, at times a workstation will be required to be remotely located, for example in the SCA or the SSDIF. Throughout all TRMM I&T activities at the TnSC the SGSE will be located in #2STA.

See Figure 7-4, TRMM Spacecraft I&T Computer System, for a block diagram of the SGSE configuration.

7.2.1 SGSE FEATURES AND CAPABILITIES

For purposes of this document, the SGSE at a minimum will contain the following features and capabilities to support the observatory I&T effort.

- database driven system
- STOL user operating system
- networks for communications, and command and telemetry data transfers between the SGSE/IGSEs
- IGSE-SGSE command interface software protocol
- offline command and telemetry database generation
- issue realtime commands to the spacecraft/instruments
- receive and handle de-commutated and decoded telemetry data
- capable of coding and decoding CCSDS telecommand and packet data formats
- store history data on storage disk (and download to tape)
- archive data storage on disk (and download to tape) and provide a method for user retrieval
- realtime data on analog history tape
- command control and interleaving of the SGSE and IGSEs
- acquisition, stripping, and display of spacecraft and instrument status and engineering data
- test procedure language (STOL) build, compiler and run module
- decision making based on telemetry data or calculated values
- offline or online limits and curves definitions
- online limit checking and notification of telemetry data out of limits
- offline page display generation and compiler
- simple data calculations
- online or history data plotting

- workstation privileges and priority scheme (the spacecraft test conductors will have control of the "master" workstation which controls the privileges and priorty of the "slave" workstations)

7.2.1.1 COMMAND AND TELEMETRY DATA BASES

The SGSE STOL system will be mnemonic driven, i.e., command and telemetry data functions will have applicable alphanumeric names. GSFC Code 733 will have the ultimate responsibility for developing the TRMM command and telemetry data bases and for creating the mnemonics. This task will be accomplished by the spacecraft test conductors. The TRMM I&T Manager will specify the guidelines to be used to develop the command and telemetry data bases. Raw or bit structured commanding and data display is possible, but not commonly utilized.

Spacecraft and instrument engineering data which are located in a fixed position in a CCSDS telemetry packet will have mnemonic names, and will be available for the SGSE to ingest for monitoring status, and health and safety items. Instrument science data and instrument data which may change telemetry packet location dependent upon instrument mode, will not be serviced by the SGSE database.

7.2.1.1.1 DATA BASE TRANSPORTABILITY

.c specified times during the I&T phase and pre-launch activities, the MOC will be involved in end-to-end testing with the TRMM Observatory for command capability checks, telemetry ingest, data base verification and rehearsal for flight operations.

Part of the MOC responsibilities is the commanding and telemetry processing of the TRMM Observatory in support of realtime on-orbit operations. This requires a data base driven system similar to that of the I&T operations.

In an effort to minimize the transition from I&T to flight operations, the TRMM I&T command and telemetry data bases will be transferred via magnetic tape (or some other electronic media) from I&T to the MOC. This will allow the MOC to operate using command and telemetry data bases verified and used during I&T.

For STOL procedure development, care should be taken to maintain "as near as possible" syntax rules as baselined in the TPOCC version of STOL to facilitate procedure transportability from I&T to MOC operations.

7.2.1.2 TELEMETRY DATA HANDLING

The following provides the data flow from its entrance into the SGSE SGDDU to the users:

Details for implementation and operation are addressed in the TRMM I&T Ground Computer System Requirements Document, document TRMM-733-095, and the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104.

- SGSE SGDDU receives the telemetry data from the frame sync, and does front-end stripping of CCSDS telemetry packets from CCSDS transfer frames,

- telemetry packet data, with header, is distributed on a LAN ethernet interface to the users,

- realtime I channel and Q channel data are distributed to the SGSE workstations and IGSEs over one physical port.

- Command, computer control signals, and online/offline history data is available on the other ethernet physical port.

7.2.1.2.1 STATUS AND ENGINEERING DATA VERIFICATION

Normally, the spacecraft and instrument status data and health and safety engineering data will be verified by the STOL Fortran-like procedure statements operating upon instantaneous telemetry data points. An online limits program will constantly monitor all data points which have a limit enable, and provide "out-of-limits" visual and audible warnings to the operator.

7.2.1.3 COMMAND HANDLING

Commands may be issued to the spacecraft or observatory from a SGSE workstation using either mnemonics or raw bit structure commands. Mnemonics will be user generated offline, and will be the primary method of commanding. IGSEs will issue commands via the ethernet interface to the SGSE. This ethernet interface will be physically separate from the telemetry distribution ethernet interface (see paragraph 7.2.1.2).

All commanding for the TRMM spacecraft subsystems shall be via the SGSE. Should the SGSE become inoperable, emergency commanding via the MCG shall be utilized; either in a single command mode, or sequences of previously loaded commands for "safing" the instruments and spacecraft. Power off sequences shall also be included.

7.2.1.3.1 COMMAND INTERLEAVE CONTROL

The SGSE will be the command input port arbitrator and interleavor.

The command handler SGDDU will service the command request from the IGSEs and the SGSE. Command requests will be temporarily buffered if other request are being serviced, then released for uplink. It will use a round-robin priority scheme to accomplish the arbitration. The SGSE will always have priority over the next IGSE in the send buffer. See the IGSE To SGSE Interface Control Document, document TRMM-733-104.

7.2.1.3.2 COMMAND SCREENING

A software program within the SGSE will contain files of valid and "allowed commands per IGSE" for each respective instrument. Checks will be performed, with appropriate responses, by the command LAN IGSE/SGSE protocol. Event messages will be broadcast for all command traffic.

(The command(s) to activate the RF output of the PR will be screened for by the SGSE and disallowed. Thus, the PR IGSE (or any other IGSE) will not have the capability to turn on the RF output of the PR. However, the PR IGSE will have the capability to turn off the RF output of the PR. Turn on of the RF output of the PR will only be allowed and performed by the spacecraft test conductor(s) and the proper command(s) can only be sent by the SGSE. (These commands will be hazardous in the SGSE command data base). At all times before the RF output of the PR is turned on, all applicable parties must give their approval.)

7.2.1.3.3 HAZARDOUS/CRITICAL COMMAND CHECKING

A software program within the SGSE shall be implemented which will check all commands requested to be executed by the SGSE against an offline generated hazardous/critical command list. Any command detected as hazardous/critical will be held in obedience until an "ALLOW" or "CANCEL" STOL keyin is entered by the spacecraft test conductor.

7.2.1.4 INSTRUMENT COMMANDING VIA THE SGSE

In general, most instrument commanding will originate at the respective instrument IGSE. Instrument command mnemonics will also be incorporated in the SGSE database. This requirement will follow into the POCC, as they are also required for flight operations. (Instrument commands will also be able to be sent by the SGSE in raw form). The definition of these commands will also be accomplished by utilizing the data base generation guidelines specified by the TRMM I&T Manager (see paragraph 7.2.1.1).

7.2.1.5 SGSE STOL TEST PROCEDURES

The SGSE will support the offline generation of STOL test procedures. Also, the SGSE will contain software to compile STOL procedures and to verify correct syntax to a limited degree. The SGSE will support online execution of STOL procedures. The SGSE can contain and support unlimited number of STOL procedures to be called for execution.

7.2.1.6 SGSE CONFIGURATION CONTROL

All software, including the operating system and data bases, shall be under configuration control after it has been debugged and functioning properly. Test runs for record purposes shall be run using the software under configuration control. All changes or enhancements to such software must be approved by the CCB.

The exception to this will be the STOL automated test procedures. STOL procedures will be under the control of the spacecraft test conductors. The testing environment requires the flexibility for the spacecraft test conductors to modify and produce test procedures to fit the need.

The spacecraft test conductors will have the latitude to make changes to STOL procedures without signoff, that correct syntax errors, or provide a better test flow, while not affecting or compromising the operation of a subsystem or instrument.

Any pre-test changes to procedures which will effect the operation of a subsystem or instrument during the conduct of an upcoming test must be reviewed and initialed by the spacecraft test conductor, the appropriate subsystem/instrument engineer, and QA.

Any changes to procedures which will effect the operation of a subsystem or instrument that take place during the conduct of the test must be red-lined, and initialed by the spacecraft test conductor, the appropriate subsystem engineer, and QA before actual execution.

The "as run" version of any major STOL test procedure shall be saved on disk and on hardcopy.

7.2.1.7 SGSE PROBLEM REPORTS AND ENHANCEMENT REQUESTS

All Software Problem Reports (SPR) or Software Enhancement Requests (SER) shall be requested in the manner prescribed in the TRMM Software Management Plan and I&T Ground System (TBD), document TRMM-TBD-TBD. It is a menu driven, user friendly software package for initiating SPRs and SERs. Its contents are stored on disk (and tape backup). Its documentation will be used in the CCB process.

7.2.2 SGSE HARDWARE

The SGSE hardware will consist of the following elements:

- 2 VME based Motorola Series 68000 computers for command and telemetry SGDDUs
- 5 IBM RS/6000 PC workstations
- 2 NCD X-Terminal workstations
- ethernet distribution
- special purpose I/O hardware
- SGSE command uplink module
- data storage (disk and tape)
- utilize ThinNet ethernet with Transmission Control Protocol / Internet Protocol (TCP/IP) for command transfers and telemetry packet distribution between users and the SGSE
- auxilliary rack for hardline command and telemetry data line differential receivers/drivers or optical converters/receivers

7.2.3 SGSE DELIVERY

The plan is that the SGSE software required for data base generation, page display generation, and STOL test procedure generation and compiling will be available before it is required by the TRMM spacecraft test conductors. his software is basically the same as the SGSE software for the X-ray Timing Explorer (XTE) Project which must be available for XTE long before it is required for TRMM, however all of these capabilities must be available 1 year in advance before the start of the electrical integration for TRMM.

The present schedule dictates that the initial TRMM SGSE all-up system will be operational at least one month prior to the start of electrical integration. This will include data base, command, page display, procedure generation, and system level checkout. This will require that the SGSE workstations be set up at least 4 months prior to this date. This will allow time for the spacecraft test conductors to install, compile, configure, and checkout, the data bases, page displays, and STOL test procedures before the start of electrical integration. The SGSE will be set up and located in the TRMM I&T operations room, building 7, room 158.

7.2.4 SGSE SPACE AND POWER REQUIREMENTS

For space and power requirements of all SGSE, see Appendix B. (Note that this appendix gives the size of each SGSE item, a reasonable amount of additional space is required for access and operation).

7.2.5 SGSE SIMULATOR

The purpose of the spacecraft interface simulator is to provide the flight-like spacecraft interfaces to the instrument. In addition, the spacecraft interface simulator simulates the SGSE by simulating the IGSE to SGSE interface that will be seen once the IGSE is integrated with the SGSE. This will not only minimize the problems and the time required to integrate the instrument to the spacecraft, but should also minimize the problems and the time required to integrate the IGSE to the SGSE. (See section 7.1.4).

7.2.6 SGSE/STOL USERS GUIDE

A SGSE/STOL Users Guide will be developed and provided by GSFC Code 733. The purpose of this document is to provide information about running the GSFC Code 733 SGSE. This includes: the STOL parser, the SGSE user interface, the graphics page editor, and the command and telemetry data base compilers.

7.3 INSTRUMENT GROUND SUPPORT EQUIPMENT

The Instrument Ground Support Equipment (IGSE) for the instruments shall be as specified in the TRMM TBD Document and Implementation Plan, document TRMM-TBD-TBD. "IGSE" is the frequently used term for only the ADP portion of the IGSE. It is understood that IGSE also includes such things as lifting slings, fixtures, external stimulus, etc. (Note that instrument lifting slings, fixtures, etc. at times are also referred to as instrument MGSE). The purpose of this section is to provide an overview of the IGSEs and specify minimal requirement.

It shall at a minimum, contain or be capable of the following:

a. provide instrument electrical / optical interfaces (for stand-alone instrument testing)
b. have an interface for command and telemetry services (for stand-alone instrument testing)
c. have an interface for command and telemetry services which meets the requirements defined in the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104 (for instrument testing via the spacecraft interface simulator and the SGSE)
d. form command packets unique to its associated instrument in conformance with the CCSDS standards, with the appropriate protocol specified in the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104
e. un-decommutated telemetry packet ingest and instrument data processing capability
f. top level data analysis
g. repeatable (and suggested automated) procedure execution (there is no requirement to match the GSFC STOL; only conform to the command format as stated in "d" above)
h. instrument stimulation
i. instrument handling and moving (instrument MGSE)

Each of the five TRMM instruments will have its own unique IGSE. The HD for each instrument is responsible for all aspects of the IGSE and shall deliver the IGSE to GSFC along with the instrument.

7.3.1 INSTRUMENT COMMANDING

Instrument commanding using its accompanying IGSE will be performed in the following ways: via the spacecraft interface simulator, directly, and via the SGSE.

7.3.1.1 INSTRUMENT COMMANDING VIA THE SPACECRAFT INTERFACE SIMULATOR

Each IGSE, when coupled with a GSFC Code 733 supplied spacecraft interface simulator, will be used to command its associated instrument during spacecraft/instrument compatability testing, and other testing as required, at the home facility where the instrument is developed. This will be performed prior to the instrument and its accompanying IGSE are delivered to the GSFC. This mode of operation is intended to emulate the mode where the instrument is commanded via the SGSE, (see paragraph 7.3.1.3).

7.3.1.2 INSTRUMENT COMMANDING VIA STAND-ALONE IGSE

Each IGSE will be used to command its associated instrument in a stand-alone mode during acceptance testing, and other testing as required, when the instrument is not mechanically or electrically connected to the TRMM Observatory. This will be performed in a similar manner as at the home facility where the instrument was developed.

7.3.1.3 INSTRUMENT COMMANDING VIA THE SGSE

As noted in paragraph 7.2.1.3, all instrument commands issued by an IGSE will be routed through the SGSE when the instrument is mechanically or electrically connected to the TRMM Observatory. In general, no commanding from an IGSE directly to the instrument will be permitted once the instrument is mechanically or electrically connected to the observatory.

7.3.2 INSTRUMENT TELEMETRY VIA THE SGSE

The SGSE will forward real-time telemetry to the IGSEs in near real-time, and optionally forward playback data in a store-and-forward mode.

7.3.2.1 REAL-TIME TELEMETRY DATA EXCHANGE

The TRMM SGSE will extract real-time instrument telemetry packets that occur in the I and Q channels, selected TRMM spacecraft housekeeping packets, annotate each packet with supplemental information relating to the origin and quality of the data, and forward the packets in "telemetry" messages to the respective IGSEs.

7.3.2.2 PLAYBACK TELEMETRY DATA EXCHANGE

Each IGSE may optionally receive playback telemetry in the store-and-forward mode by having an open network connection for Q channel data during periods of playback. During periods of playback, the SGSE will extract packets from the playback telemetry stream as it is being downlinked, format the telemetry as "telemetry" messages in the same format as the real-time "telemetry" messages, and forward the messages to the respective IGSEs. If an IGSE does not wish to receive the playback, it shall "close" its Q channel socket during periods of telemetry playback. It shall be the spacecraft test conductor's responsibility to verbally notify the instrument test teams when a playback is to begin.

7.3.2.3 TELEMETRY PACKET SELECTION

Each instrument test team shall identify the list of CCSDS telemetry packets that it wants the SGSE to distribute to their respective IGSE at least 1 month prior to the integration of the IGSE with the SGSE. This list may be amended at any time with mutual consent of the spacecraft I&T team and each instrument team. (Note that each IGSE is not limited to telemetry packets directly related to each respective instrument. IGSEs can receive telemetry packets from other instruments or from spacecraft subsystems which might contain telemetry data and information useful to the instrument.)

7.3.2.4 INSTRUMENT DATA ANALYSIS

The instrument data analysis will be performed by each of the respective instrument IGSEs, and shall be the responsibility of the cognizant Instrument Managers. Each IGSE shall have the needed capability to fully analyze its instrument data verifying correct operation and performance of the instrument.

7.3.3 IGSE SOFTWARE

The IGSE software for each instrument will be developed and tested by the instrument/IGSE developers during their developmental phase prior to delivery to the GSFC. This includes command and data handling, automated testing using pre-written procedures, data analysis, etc.

Each of the IGSEs will be capable of stand-alone, IGSE to spacecraft interface simulator, and IGSE to SGSE modes of operation. For the latter two modes of operation, the protocols as established in the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104 shall be be followed.

7.3.3.1 INSTRUMENT TEST PROCEDURES

Instrument test procedures shall reside in each respective IGSE. These procedures will be used to operate and test the instrument during the TRMM I&T effort. In general, these procedures should have been previously defined, generated, and tested prior to the instrument being delivered to the GSFC. It is suggested that these procedures be "canned" procedures which will run automatically when requested, and therefore can be repeated as needed throughout the TRMM I&T effort. (However, test procedures being of either the automatic or manual type should be repeatable so they can be executed many times throughout the I&T program verifying similar results). Dependent upon the IGSE system, these procedures may be "STOL like" or in a different language.

7.3.4 IGSE CONFIGURATION CONTROL

Each instrument test team will be responsible for having their own GSE :onfiguration control in place. The following caviates apply:

- Each shall abide by the hardware and software interfaces established in the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104.

- Any changes or modifications which would effect the IGSE/SGSE interface, or the method(s) of commanding or receiving telemetry data from the established CCSDS and SGSE standards shall have TRMM project approval before implementation.

- Any changes or modifications which would affect any instrument MGSE compatability with any GSFC MGSE or mechanical handling or operations at GSFC shall have TRMM project approval before implementation.

7.3.5 SPECIAL IGSE AND TEST REQUIREMENTS

During the TRMM I&T effort, some of the TRMM instrument (if not all) will require special testing. This testing will require the use of special IGSE provided by the instrument developers. The details and plans for these special tests and required IGSE shall be specified in the test plan for each respective instrument (see paragraph 7.3.7). In addition, special IGSE will be provided by the instrument developers for handling and for the mechanical installation of each instrument.

7.3.6 INSTRUMENT STIMULUS

During the TRMM I&T effort, some of the TRMM instruments (if not all) will require an external stimulus to verify the proper operation and calibration of the instrument. The details and plans for this requirement and operation shall be specified in the test plan for each respective instrument (see paragraph 7.3.7).

7.3.7 INSTRUMENT TEST DOCUMENTATION

Each TRMM instrument test team shall prepare and provide an instrument test plan. The intent of this document is to provide an informal written overview of the I&T activities expected and required during the TRMM I&T effort for each instrument. This document will be used as a tool by the TRMM I&T Manager for planning instrument I&T activities. Special consideration should be given to any special tests and use of special IGSE.

7.3.8 IGSE SPACE AND POWER REQUIREMENTS

For space and power requirements for the various IGSEs, see Appendix B. (Note that this appendix gives the size of each IGSE item, a reasonable amount of additional space is required for access and operation).

7.4 MECHANICAL GROUND SUPPORT EQUIPMENT

The purpose of this section is to provide an overview of the Mechanical Ground Support Equipment (MGSE) requirements for the TRMM Spacecraft and Observatory harness fabrication (spacecraft mock-up), I&T activities at GSFC, transportation to the launch site, and launch site activities at TnSC. (See the TRMM Mechanical Integration And Test Flow Plan, document TRMM-722-AP-001 for more detailed information).

GSFC Code 722 is responsible for providing the MGSE required for most spacecraft and observatory level I&T activities, with certain exceptions; e.g., subsystem/instrument handling and lifting slings. Also, GSFC Code 722 is responsible for the MGSE required for the transport of flight hardware to the launch site. GSFC Codes 722, 750, and 234 and TnSC personnel through a coordinated effort will provide all MGSE required at the launch site.

The OHA requirements as addressed in the applicable spacecraft moving and crane operations plan and procedures shall be followed.

(The procedures set forth in the GSFC Code 303 Procedure P-303-857, Lifting Of Space Flight Hardware shall be followed for all lifting operations involving space flight hardware).

7.4.1 SPACECRAFT MOCK-UP

A full size mock-up structure of plywood and sheet metal construction has been provided to GSFC Code 733 by Code GSFC 722 for electrical and fiber optics harness fabrication. In addition, the mock-up will be used for fit and routing checks for the RF cable assemblies, and for planning the routing of the plumbing for the RCS thrusters. The mock-up contains structure elements and simulated electronic boxes, with connectors, mounted on it to flight dimensions. This mock-up has been available since December 1993 and will remain available through the start of I&T. The mock-up is located in the high-bay of GSFC building 20 where the flight harness fabrication is taking place.

7.4.2 SPACECRAFT AND OBSERVATORY I&T MGSE

The basic elements of the MGSE include:

- Handling fixtures
- Standard mechanical tools and hardware
- Observatory transporter and shipping containers

7.4.2.1 HANDLING FIXTURES

Unique fixtures are to be developed to move, lift, support, and otherwise handle the spacecraft/observatory, its instruments, and components. This equipment includes:

- Spacecraft/Observatory Scaffolding
- TRMM Vertical Dolly
- TRMM Rotating/Transportation Dolly
- TRMM Vertical Lift Sling
- TRMM Horizontal/Rotating Dolly Lift Sling (sling has two configurations)
- Equipment Panel Sling/Stiffener Assembly
- RWM Lift Sling
- PTM Installation MGSE
- Gravity Negation And Deployment Test MGSE
- Subsystem/Instrument Lifting, Handling, And Installation MGSE (as required)
- Payload Attach Fitting (the flight and test PAF are provided by NASDA)
- Miscellaneous And Other MGSE (as required)

See the TRMM Mechanical Integration And Test Flow Plan, document TRMM-722-AP-001 for more detailed information on the MGSE and how it will be used.

All lifting and moving equipment shall be proof tested as per the TRMM Verification Plan, document TRMM-750-113.

All handling fixtures shall meet the cleanliness design and material requirements of the TRMM Contamination Control Plan, document TRMM-732-016. Wood is an unacceptable material. The use of organic lubricants is to be minimized and, if they must be used, design measures shall be taken to prevent accidental contamination of flight hardware (e.g., use of covers, bagging, sealed joints). If dry lubricants generate particles, the design shall be such as to prevent the particles from contaminating the flight hardware.

7.4.2.1.1 SPACECRAFT/OBSERVATORY SCAFFOLDING

Due to the physical size of the TRMM Spacecraft/Observatory, scaffolding will be required to provide complete lateral access to the spacecraft/observatory. This includes complete access to the spacecraft/observatory while it is in the vertical dolly in the vertical orientation or while it is in the TRMM rotating/transportation dolly in the horizontal orientation. In order to achieve this requirement, a multi-story scaffold will be required. Also, the scaffolding must allow the four equipment panels to open freely while the spacecraft/observatory is contained in the vertical dolly.

The scaffolding shall be constructed from iridited aluminum with a grated surface to insure better traction for personnel. It shall contain bolt-down points for electrically bonding the different sections together and for grounding. The TRMM Electrical Subsystem Lead Engineer shall insure its electrical integrity per the TRMM ESD Control Implementation Plan, document TRMM-733-054.

The I&T Stand/Scaffolding shall remain in the SCA during initial I&T activities and will be relocated along with the observatory to the SSDIF and will remain there throughout the duration of I&T.

7.4.2.1.2 TRMM VERTICAL DOLLY

A dolly will be provided to support the spacecraft/observatory in the vertical position. The spacecraft/observatory will be in this dolly throughout most (if not all) I&T activities occurring within the SCA, for a portion of the I&T activities occurring within the SSDIF, and for a portion of the observatory checkout activities occurring at the launch site. Also, this dolly will generally be used for intra-building transportation (SCA/SSDIF to/from environmental test sites) of the spacecraft/observatory. In addition, this dolly contains a turntable capable of indexing the observatory in 10 degree increments. (See Figure 7-5, TRMM Vertical Dolly).

7.4.2.1.3 TRMM ROTATING/TRANSPORTATION DOLLY

A dolly will be provided to rotate the spacecraft/observatory to/from the vertical position to/from the horizontal position. (Each of the four sides of the spacecraft/observatory (+Y, -Y, +Z, -Z) can be configured downward using this dolly). This dolly will be used to support the spacecraft/observatory for various I&T activities which require a horizontal orientation (e.g., solar array deployment tests, HGA/TMI deployment tests, instrument mechanical integrations, TMI and other functional tests). This dolly can also provide intra-building transportation of the spacecraft/observatory in the horizontal position. This dolly is equipped with air-pads used to facilitate its movement. In addition, this dolly will be used (in a different configuration) to support the observatory during shipment to the launch site. (See Figure 7-6, TRMM Rotating/Transportation Dolly).

7.4.2.1.4 TRMM VERTICAL LIFT SLING

A vertical lifting sling will be provided for spacecraft/observatory lifting in the vertical position. It will be used for numerous lifts: between MGSE, to/from various test facilities, etc. (See Figure 7-7, TRMM Vertical Lift Sling).

.4.2.1.5 TRMM HORIZONTAL/ROTATING DOLLY LIFT SLING (OBSERVATORY CONFIGURATION)

A horizontal lifting sling will be provided for spacecraft/observatory lifting in the horizontal position. (See Figure 7-8, TRMM Horizontal/Rotating Dolly Lift Sling (Observatory Configuration)).

7.4.2.1.6 TRMM HORIZONTAL/ROTATING DOLLY LIFT SLING (DOLLY CONFIGURATION)

The TRMM Horizontal/Rotating Dolly Lifting sling can be configured to be used for lifting the observatory along with the TRMM rotating dolly into and out of the TRMM Observatory transporter (shipping container). (See Figure 7-9, TRMM Horizontal/Rotating Dolly Lift Sling (Dolly Configuration)).

7.4.2.1.7 EQUIPMENT PANEL SLING/STIFFENER ASSEMBLY

The TRMM Observatory contains four equipment panels which can be removed (although not desirable) during I&T (even when fully loaded with electronics boxes). An equipment panel sling/stiffener assembly will be provided to attach or remove these panels. The "stiffener" serves as a means to prevent bending or twisting of the panel during the attachment or removal process. (See Figure 7-10, Equipment Panel Sling/Stiffener).

7.4.2.1.8 RWM LIFT SLING

A RWM lifting sling will be provided for lifting and installation operations of the RWM. (The reaction wheels and the reactions wheel electronics (4 of each) will be mechanically installed into the RWM and the reaction wheels will be mechanically aligned prior to the installation of the RWM into the spacecraft. Once the RWM has been mechanically integrated into the spacecraft it will also be mechanically aligned.)

7.4.2.1.9 PTM INSTALLATION MGSE

PTM installation MGSE will be provided to install the flight PTM into the spacecraft LBS. The PTM installation MGSE consists of the following:

- PTM Lifting Sling
- PTM Installation Stand
- Rollable Scissor Jack
- PTM Floating Table With Guides

A PTM lifting sling will be provided for lifting operations of the PTM. (See Figure 7-11, PTM Lifting Sling).

The PTM installation stand will be provided to support the installation of the flight PTM into the spacecraft LBS. Its purpose is to support the spacecraft at an elevation of 10 feet during the installation process. (See Figure 7-12, PTM Installation Stand).

A rollable scissor jack will be provided to support the installation of the flight PTM into the spacecraft LBS. Its purpose is to provide a platform for lifting the PTM up into the spacecraft LBS.

A PTM floating table with guides will be provided to support the installation of the PTM into the spacecraft LBS. Its purpose is to provide alignment and fine positioning adjustments during as the PTM is installed into the spacecraft LBS. (See Figure 7-13, PTM Floating Table, also see Figure 7-14, PTM Installation).

7.4.2.1.10 GRAVITY NEGATION AND DEPLOYMENT TEST MGSE

Gravity negation fixtures will be provided by the Deployables Subsystem Lead Engineer (GSFC Code 722) for deployment testing of the solar array wings. Currently, the baseline is that low friction air pads/tables will be used which will require a source of clean pressurized air.

Manually operated MGSE will be provided as required by GSFC Code 722 for deployment testing of the HGAD/PS. Additional, manually operated MGSE will be provided as required by the TMI Instrument developer for deployment testing of the TMI bucket and antenna.

7.4.2.1.11 SUBSYSTEM/INSTRUMENT LIFTING SLINGS, HANDLING AND INSTALLATION MGSE

Lifting slings, handling and installation MGSE will be provided to lift, handle, and to support the installation of spacecraft subsystem components and instruments as required. (Instrument providers are required to provide required instrument MGSE).

7.4.2.1.12 PAYLOAD ATTACH FITTING

A test Payload Attach Fitting (PAF) will be provided by NASDA to support TRMM testing activities at the GSFC. At a minimum the observatory will be mounted to the PAF during the vibration, acoustics, and mechanical shock test. In addition, NASDA will provide the flight PAF for a fit check with the observatory. This will be performed at the GSFC (see the TRMM Project Schedule Baseline Document, document TRMM-490-165 for the schedule date).

7.4.2.1.13 MISCELLANEOUS AND OTHER MGSE

Miscellaneous and other MGSE will be provided for various purposes. This MGSE includes a vibration table to spacecraft interface plate, a MPMF to spacecraft interface plate, a ramp between the SCA and the EMI shield room, etc. (This MGSE will be provided by GSFC Code 722 and/or GSFC Code 750 as required).

7.4.2.2 STANDARD MECHANICAL TOOLS AND HARDWARE

Various standard mechanical tools and hardware will be required to support TRMM I&T activities which are mechanical in nature. These tools and hardware might include torque wrenches, cap socket head screws, flat washers, etc.

7.4.2.3 OBSERVATORY TRANSPORTER AND SHIPPING CONTAINERS

An Observatory shipping container will be provided for transport of the TRMM Observatory from the GSFC to the TnSC in Japan. This shipping container will be sealed and environmentally controlled by an air conditioning cooler/heating system known as the Environmental Control System (ECS). Also, the container is capable of being under a constant purge of gaseous nitrogen. Equipment will be incorporated into the container to provide monitoring of temperature, humidity, and mechanical shock. A transporter will also be provided. The transporter will contain an air-ride trailer which will be used for ground transportation in the United States and possibly in Japan (if the transporter is not shipped to Japan, a Japanese transporter will be required). The container shall be transportable on a C-5A cargo jet or possibly on other TBD wide-body cargo jets. This transporter/shipping container is a new system being procured under a joint venture between the XTE and TRMM Projects to be used by each. (See Figure 7-15, TRMM/XTE Shipping Container, and Figure 7-16, TRMM/XTE Transporter).

Various shipping containers will be required to transport both flight hardware elements and GSE from the GSFC to the TnSC in Japan. The flight hardware elements requiring shipping separate from the observatory include the solar arrays, the flight batteries (provided by GSFC Code 734), and possibly the HGA. All GSE required at TnSC will be required to be packed and shipped in some sort of protective shipping container.

All shipping containers shall meet the cleanliness requirements of the TRMM Contamination Control Plan, document TRMM-732-016.

7.4.3 MGSE DELIVERY

The MGSE described throughout this document (and any that is not) will be required at various times to support the TRMM I&T effort. It is expected that all MGSE will be provided in a timely manner to support the various I&T tasks as required. See the TRMM Mechanical Integration And Test Flow Plan, document TRMM-722-AP-001 for an overview of all I&T operation which are mechanical in nature and what MGSE is required to support these operations. Also, see the TRMM Project Schedule Baseline Document, document TRMM-490-165 for the schedule of these operations.

7.4.4 MGSE SPACE AND POWER REQUIREMENTS

For space and power requirements of all MGSE, see Appendix B. (Note that this appendix gives the size of each MGSE item, a reasonable amount of additional space is required for access and operation).

7.5 BATTERY GROUND SUPPORT EQUIPMENT

The purpose of this section is to provide an overview of the Battery Ground Support Equipment (BGSE) requirements for the TRMM Spacecraft and Observatory I&T activities at GSFC and launch site activities at TnSC.

GSFC Code 734 is responsible for providing the BGSE required for all spacecraft and observatory level I&T activities. Also, GSFC Code 734 is responsible for the proper operation of all BGSE.

The basic elements of the BGSE include:

- Data Acquisition Rack #1
- Data Acquisition Rack #2
- BGSE Printer
- Battery Air Conditioner
- Battery Cooling Cart

7.5.1 DATA ACQUISITION RACK #1

The Data Acquisition Rack #1 contains the computer control system to control and monitor both batteries simultaneously. Although the batteries are integrated onto the spacecraft and the spacecraft has the capability to monitor and control the batteries, it is unpowered for many periods of time. When the spacecraft is unpowered (or the batteries are offline), the data acquisition rack #1 controls the charging/discharging and cycling of the batteries and provide continuous monitoring.

The data acquisition rack #1 will be used to control and monitor the batteries (both test and flight), whenever possible and practical, starting once they are integrated onto the spacecraft at the GSFC until launch at the TnSC (this includes use on the gantry).

7.5.2 DATA ACQUISITION RACK #2

The Data Acquisition Rack #2 accompanies the data acquisition rack #1. It contains the power supplies, loads, relays, and other related hardware used to perform the simultaneous charging/discharging, cycling, and monitoring of both batteries. This rack is controlled by the data acquisition rack #1.

Along with data acquisition rack #1, data acquisition rack #2 will be required, whenever possible and practical, starting once the batteries (both test and flight) are integrated onto the spacecraft at the GSFC until launch at the TnSC (this includes use on the gantry).

7.5.3 BGSE PRINTER

The BGSE Printer is used to record in the form of a hardcopy the charging/discharging and cycling operations performed on the batteries. In addition, the battery currents and temperatures, and the voltages for each cell are recorded on a periodic basis. The BGSE printer interfaces to the data acquisition rack #1.

Along with the data acquisition racks, the BGSE printer will be required to record battery data, whenever possible and practical, starting once the batteries (both test and flight) are integrated onto the spacecraft at the GSFC until launch at the TnSC (this includes use on the gantry).

7.5.4 BATTERY AIR CONDITIONER

The Battery Air Conditioner is a general purpose air conditioner which will be used to provide additional cooling for the batteries while they are on the spacecraft. The air will be ducted into the spacecraft so the flow will be directly onto the batteries.

The battery air conditioner will be required to cool the batteries, whenever possible and practical (this includes both when they are and are not online). This requirement starts once the batteries (both test and flight) are integrated onto the spacecraft at the GSFC until launch at the TnSC (this includes use on the gantry).

7.5.5 BATTERY COOLING CART

The Battery Cooling Cart is used to cool the batteries (both test and flight) while they are being reconditioned. It contains a flat cold plate surface which the batteries are mounted. Therefore this cart can only be used to cool the batteries when they are not integrated to the spacecraft.

The only planned time the battery cooling cart will be required during I&T is at the launch site. The flight batteries will be shipped to the launch site separate from the observatory. Once both the flight batteries and the observatory arrive at the launch site the flight batteries will be reconditioned before they are integrated onto the observatory. This reconditioning will require the battery cooling cart.

7.5.6 BGSE DELIVERY

As noted in paragraph 7.5, GSFC Code 734 is responsible for providing and operating the BGSE. Since the BGSE (except for the battery cooling cart) is required essentially all the time, the BGSE shall be delivered to the spacecraft just prior to when either the test or flight batteries are to be integrated onto the spacecraft. From that point on through launch, where and whenever possible and practical, the BGSE (except for the battery cooling cart) shall accompany the spacecraft (this includes all I&T facilities). The battery cooling cart shall be shipped to the launch site along with the other BGSE for its use there.

7.5.7 BGSE SPACE AND POWER REQUIREMENTS

For space and power requirements of all BGSE, see Appendix B. (Note that this appendix gives the size of each BGSE item, a reasonable amount of additional space is required for access and operation).

7.6 INTEGRATION PROCEDURES

The overall intent of an integration procedure is to provide an orderly and precise plan for the task at hand. For the TRMM Observatory three types of integration procedures will be required (see Figure 7-17, TRMM I&T Procedure Tree). These are:

- Mechanical Integration Procedures
- Optical Bus Integration Procedures
- Electrical Integration Procedures

7.6.1 MECHANICAL INTEGRATION PROCEDURES

Mechanical integration is defined as the process of mechanically installing a subsystem, instrument, or component onto the TRMM Spacecraft or Observatory. A mechanical integration procedure is a written document that details the steps to be performed to accomplish this task in an orderly and precise manner. A mechanical integration procedure will be required for each separate subsystem or instrument box or component to be installed onto the TRMM Spacecraft or Observatory. (The mechanical integration procedures shall contain a section to reverse the process, i.e., mechanical de-integration).

The preparation and delivery of the mechanical integration procedures will be the responsibility of the applicable lead enginner or manager responsible for the subsystem or instrument. The mechanical subsystem lead engineer is required to supply information and assistance as needed. The guidelines described in paragraph 7.6.1.1 will be used for the preparation of these procedures. (Examples are also available from the TRMM I&T Manager).

7.6.1.1 MECHANICAL INTEGRATION PROCEDURE PREPARATION GUIDELINES

In addition to the generic "boilerplate" sections, a mechanical integration procedure shall contain an orderly detailed step by step sequence of events to safely install the component onto the TRMM Spacecraft or Observatory. For consistency purposes, the following mechanical integration procedure outline shall be utilized:

* Front Cover Page
  - Document number (assigned by the TRMM CMO), Revision
  - Project, Component (e.g. Transponder), Mechanical Integration Procedure indicated
  - Date
  - Originating Center

* Configuration Controlled Document Page

* Revision Page

* Signature Page(s)

* Table Of Contents

* Section 1. Introduction
  - Purpose of procedure
  - Scope of procedure
  - Subsystem/Instrument/Component description
  - Responsible I&T personnel
  - General description of the integration process
  - Changes to the procedure (deviations)

* Section 2. Support Requirements
  - Applicable Drawings and Documentation
  - Required Materials, Tools, Parts, MGSE, and Test Equipment

* Section 3. Special Considerations
  - Personnel safety
  - Hardware safety, ESD protection
  - Flight Connector mate and demate operations
  - Contamination
  - Environment (temperature/humidity)

* Section 4. Pre-Mechanical Integration Operations
  - Precautions
  - Unpacking
  - Visual Inspection
  - Connector Inspection
  - Weighing
  - Spacecraft configuration prerequisite and other constraints
  - Mounting Surface flatness tolerances

* Section 5. Detailed Mechanical Integration Operations
  - Cleaning Mating Surfaces
  - Mounting Holes Alignment Checks and Component Installation
  - Connector Alignment Checks
  - Component Serial Number
  - Component Electrical Ground Verification

* Section 6. Detailed Mechanical De-Integration Operations

* Figures, Tables, And Appendices
  - Acronyms and Abbreviations
  - Deviations Log

7.6.2 OPTICAL BUS INTEGRATION PROCEDURES

Optical Bus integration is defined as the process of connecting the optical harness to the star couplers and verifying the integrity of the optical bus. An optical bus integration procedure is a written document that details the steps to be performed to accomplish this task in an orderly and precise manner. An optical bus integration procedure will be required for each separate bus on the TRMM Observatory.

The preparation and delivery of the optical bus integration procedures will be the responsibility of the Electrical Subsystem Lead Engineer. The electrical harness lead engineer is required to supply information and assistance as needed. The guidelines described in paragraph 7.6.2.1 will be used for the preparation of these procedures.

7.6.2.1 OPTICAL BUS INTEGRATION PROCEDURE PREPARATION GUIDELINES

In addition to the generic "boilerplate" sections, an optical bus integration procedure shall contain an orderly detailed step by step sequence of events to safely mate the optical harness to the star couplers and to verify the integrity of the optical bus. For consistency purposes, the following optical bus integration procedure outline shall be utilized:

* Front Cover Page
  - Document number (assigned by the TRMM CMO), Revision
  - Project, Optical Bus (e.g. ACS Optical Bus), Optical Bus Integration Procedure indicated
  - Date
  - Originating Center

* Configuration Controlled Document Page

* Revision Page

* Signature Page(s)

* Table Of Contents

* Section 1. Introduction
  - Purpose of procedure
  - Scope of procedure
  - Optical Bus description
  - Responsible I&T personnel
  - General description of the integration process
  - Changes to the procedure (deviations)

* Section 2. Support Requirements
  - Applicable Drawings and Documentation
  - Required Test Equipment

* Section 3. Special Considerations
  - Personnel safety
  - Hardware safety, ESD protection
  - Flight Connector mate and demate operations
  - Contamination
  - Environment (temperature/humidity)

* Section 4. Pre-Optical Bus Integration Operations
  - Precautions
  - Component Serial Number
  - Connector Inspection

* Section 5. Detailed Optical Bus Integration Operations
  - Optical Harness Cleaning, Inspection, and Mating to Star Couplers
  - Optical Harness Integrity Verification and Attenuation Checks

* Figures, Tables, And Appendices
  - Acronyms and Abbreviations
  - Deviations Log

7.6.3 ELECTRICAL INTEGRATION PROCEDURES

Electrical integration is defined as the process of electrically interfacing a subsystem, instrument, or component with the TRMM Spacecraft or Observatory. An electrical integration procedure is a written document that details the steps to be performed to accomplish this task in an orderly and precise manner. An electrical integration procedure will be required for each separate subsystem or instrument box or component to be electrically connected to the TRMM Spacecraft or Observatory.

The preparation and delivery of the electrical integration procedures will be the responsibility of the applicable lead engineer or manager responsible for the subsystem or instrument. The electrical subsystem lead engineer is required to supply information and assistance as needed. Also, the applicable spacecraft test conductor will be available to provide assistance as needed. The guidelines described in paragraph 7.6.3.1 will be used for the preparation of these procedures. (Examples are also available from the TRMM I&T Manager).

7.6.3.1 ELECTRICAL INTEGRATION PROCEDURE PREPARATION GUIDELINES

In addition to the generic "boilerplate" sections, an electrical integration procedure shall contain an orderly detailed step by step sequence of events to electrically interface the component in a safe manner with the TRMM Spacecraft or Observatory. For consistency purposes, the following electrical integration procedure outline shall be utilized:

* Front Cover Page
  - Document number (assigned by the TRMM CMO), Revision
  - Project, Component (e.g. Transponder), Electrical Integration Procedure indicated
  - Date
  - Originating Center

* Configuration Controlled Document Page

* Revision Page

* Signature Page(s)

* Table Of Contents

* Section 1. Introduction
  - Purpose of procedure
  - Scope of procedure
  - Subsystem/Instrument/Component description
  - Responsible I&T personnel
  - General description of the integration process
  - Changes to the procedure (deviations)

* Section 2. Support Requirements
  - Applicable Drawings and Documentation
  - Required Test Equipment, BOBs, GSE, etc.

* Section 3. Special Considerations
  - Personnel safety
  - Hardware safety, ESD protection
  - Flight Connector mate and demate operations
  - Contamination
  - Environment (temperature/humidity)

* Section 4. Pre-Electrical Integration Operations
  - Precautions
  - Component Serial Number
  - Component Electrical Ground Verification
  - Connector Inspection

* Section 5. Detailed Electrical Integration Operations
  - BOB Installation
  - Continuity and Isolation checks
  - Unloaded Input Voltage Checks
  - Loaded Input Voltage And Current Checks
  - Transient In-rush Current Checks
  - AC Noise Voltage Checks
  - Optical Harness Cleaning, Inspection, and Mating
  - 1 Hz Pulse Checks (if applicable)
  - Low Power / Safehold Pulse Checks (if applicable)
  - Applicable Command And Telemetry Interface Checks
  - Applicable Electrical I/O Interface Checks
  - BOB Removal and Electrical Harness Mating

* Figures, Tables, And Appendices
  - Acronyms and Abbreviations
  - Deviations Log

The following information, where applicable, should also be included in Section 5., Detailed Electrical Integration Operations:

- Any Special Spacecraft/Instrument configuration requirements
- Description of electrical signals and waveforms, specifications
- Identify all connectors by number and side (box or harness)
- Identify function of all active pins checked
- Expected values with tolerances
- Signal photographing requirements

7.6.4 INTEGRATION PROCEDURE SIGN OFF

All integration procedures shall be completed and ready for review at least six weeks prior to the expected execution date. The drafted integration procedure shall be given to the I&T coordinator who will make copies and send them out for review. The review period shall not exceed two weeks. All comments shall be forward to the procedure developer for consideration and/or incorporation. A final version of the integration procedure shall be delivered to the I&T coordinator two weeks prior to the expected execution date. The I&T coordinator will acquire the needed signatures. The final signed off procedure should be completly ready for execution one week prior to the expected execution date. The I&T manager will determine the expected execution dates for procedures.

Integration procedures shall be reviewed and signed off by the following personnel:

- Document Preparer
- Subsystem lead engineer or Instrument Manager
- Applicable Spacecraft Test Conductor (for electrical integration procedures)
- Mechanical or Electrical subsystem lead engineer
- Interfacing subsystem lead engineers

Integration procedures shall be approved and signed off by the following personnel:

- I&T Manager
- FAM
- Observatory Manager

7.7 FUNCTIONAL TESTS AND PROCEDURES

This section describes the major types of functional tests which will be developed to test the TRMM Observatory. Also, this section describes how these functional tests, in the form of STOL test procedures, will be used to test the TRMM Observatory. (See Figure 7-17, TRMM I&T Procedure Tree).

7.7.1 FUNCTIONAL TESTS

Functional tests shall generally be categorized into the performance or "long form" functional test , a "short form" functional test, an "aliveness" test, or an array of special function tests.

7.7.1.1 PERFORMANCE/LONG FORM FUNCTIONAL TEST

The purpose of a performance test, also known as a long form functional test, is to demonstrate and validate that a subsystem or instrument is performing in accordance with cited specifications. The long form functional test is the most detailed and comprehensive test. It is an orderly arrangement of commands, telemetry verifications, displays of data, etc., which is repeatable from test to test. This test shall contain comprehensive checks of all electrical, software (if applicable), and electro-mechanical functions. (This may require the use of external sources, stimuli, and GSE). Its time duration varies from subsystem/instrument to subsystem/instrument depending upon its complexity.

Long form functional test for each subsystem and instrument will be required. They will be combined to form an observatory long form functional test. This test will be known as the observatory comprehensive performance test. This test will be performed at various key points throughout the TRMM I&T schedule. The initial observatory comprehensive test shall verify that the observatory performance requirements are met within allowable tolerances and will be used as the baseline for later performance tests, with allowance for any changes which may have been made.

The naming conventions specified by the TRMM I&T Manager will be used by the spacecraft test conductors to name the long form functional tests. Using these guidelines the name of the observatory comprehensive performance test might be "OBSLONG" or "OBSLFF". Similar for example, the name of a long form function for the ACS might be "ACSLONG" or ACSLFF".

7.7.1.2 SHORT FORM FUNCTIONAL TEST

A short form functional test is an abbreviated version of the long form functional test, and shall be performed when the long form functional test is not warranted or practicable. It shall be used to demonstrate and validate that a subsystem/instrument is performing in accordance with cited specifications. Its time duration varies from subsystem/instrument to subsystem/instrument depending upon its complexity, however, generally its duration is approximately half that of a long form functional test. Similar to the long form functional test, these tests for each subsystem and instrument can be combined to form a short form functional test for the observatory. Naming conventions similar to the long form functional tests applies, e.g., the name of the short form functional test for the ACS might be "ACSSHORT" or "ACSSFF", and the name of the short form functional test for the observatory might be "OBSSHORT" or "OBSSFF". A short form functional test will be required for each subsystem and instrument (if feasible). Also, an observatory level short form functional test will be required.

7.7.1.3 ALIVENESS TEST

An aliveness test shall include a power on sequence, and a minimal number of commands and telemetry checks to verify the component is "alive" and operational. Its time duration is usually less than 15 minutes per subsystem or instrument. Similar to the long and short form functional tests, these tests for each subsystem and instrument can be combined to form an aliveness test for the observatory. Naming conventions similar to the long form functional tests applies, e.g., the name of the aliveness test for the ACS might be "ACSALIVE", and the name of the aliveness test for the observatory might be "OBSALIVE". An aliveness test will be required for each subsystem and instrument. Also, an observatory level aliveness test will be required.

7.7.1.4 LAUNCH CONFIGURATION AND VERIFICATION TEST

Just prior to the performance of observatory level environmental test, i.e., vibration, acoustics, and the mechanical shock test, during the launch rehearsals, and just prior to the actual launch of the TRMM Observatory, the observatory must be placed and verified in a predefined configuration. A test will be developed to place the observatory into this configuration and to verify that this configuration is correct.

7.7.1.5 SOLAR ARRAY AND ANTENNA BOOM DEPLOYMENT TEST

Solar array and antenna boom deployment tests will be required to verify that these deployables will function in the manner attended. Although these tests contain many mechanical and manual operations, the spacecraft test conductors will generate STOL test procedures for these tests. The STOL test will not only be written to contain the normal STOL functions, (i.e., commands, telemetry verifications, etc.) but will also include comments and "hard waits" for periods where a mechanical or manual operation is to take place. This will allow the spacecraft test conductor to direct and control the overall test and to verify that all required operations are performed. Once these operations are complete, the test conductor will resume the procedure. The purpose of these tests are to verify:

* proper mechanical operation
  - verify no binding at hinge points
  - verify that latching mechanisms lock at the end-of-travel
  - verify proper clearances
  - verify cable interfaces do not bind with themselves, or the structure, and have proper bend radii
  - verify the overall mechanical design and operation

* proper electrical operation
  - verify that all connector interfaces work properly before, during, and after the deployment sequence
  - verify proper operation of the electronic deployment sequencer
  - verify proper operation of the deployable position/latch indicators
  - verify proper operation of the pyrotechnic circuits and devices
  - verify PAF connector interface
  - verify the overall electrical design and operation

7.7.1.6 SPACECRAFT LAUNCH SEQUENCER TEST

A spacecraft sequencer circuit within the SPSDUs will provide signals to activate pyrotechnic devices for deployables at pre-determined times. Also, this sequencer will power on any desired onboard system, i.e, the reaction wheels, a transmitter, etc., at pre-determined times. The sequencer operation is initiated by switch closures from the H-II PAF connector interface. These signals may be derived from either the H-II launch vehicle or by the umbilical console PAF interface panel (sequencer test panel, see paragraph 7.1.1). These tests will be run periodically to validate the sequencer operation, and/or the H-II PAF interface.

7.7.1.7 SPACECRAFT PYROTECHNIC CIRCUITS AND INITIATOR TESTS

.ssociated with the tests addressed in paragraph 7.7.1.6, are spacecraft pyrotechnic circuits and initiator tests. All pyrotechnic circuits will be tested and verified periodically during the TRMM I&T and pre-launch activities. A portable pyrotechnic test box will be utilized (see paragraph 7.1.7.2) for verifying the initiator resistances, and providing a simulated load with monitoring capability, when the pyrotechnic firing pulses are provided by the spacecraft.

7.7.1.8 MISCELLANEOUS TESTS

There are various miscellaneous tests which will be performed throughout the TRMM I&T activities. These tests include: spacecraft power on tests, spacecraft configuration and mode change tests, spacecraft safehold tests, spacecraft power down tests, etc. During the course of I&T there is always a need for additional testing not specifically addressed in the various plans. These may include troubleshooting, data verification, calibrations, special instrument data analysis test, and the like.

7.7.2 FUNCTIONAL TEST PROCEDURES

Automated or repeatable functional test procedures will be utilized as the primary means for functionally testing the spacecraft and observatory throughout all phases of the TRMM I&T effort. These test procedures will either reside and be executed from the SGSE or from the IGSE for each respective instrument.

7.7.2.1 SGSE-OBSERVATORY FUNCTIONAL TEST PROCEDURES

The automated STOL test procedures, commonly referred to as "procs", will support functional testing of the TRMM Spacecraft and Observatory. They will be written in a "top down" manner. STOL will be used as the interactive element from user to machine. They will execute a script of pre-defined commands, provide telemetry data verification, page display calls, etc. to perform unique or multiple functions. These procs range from short unique purposes, e.g., a proc to turn on/off a relay, to an observatory level long form performance proc.

The development and delivery of all spacecraft and observatory level procs to reside in the SGSE will be the responsibility of the spacecraft test conductors. However, the subsystem/instrument engineers are responsible for the contents and flow of each proc, or portion of a proc, that relates to their respective subsystem or instrument. Also, it will be the responsibility of the respective subsystem/instrument engineer to provide the spacecraft test conductor(s) with a script or outline containing all of the necessary information for creating all required STOL test procedures. (Instrument test procedures residing in the SGSE will be limited, see paragraph 7.7.2.2.1).

As soon as the command and telemetry data base is mature and page display generation is well under way, the spacecraft test conductors shall start developing under their own accord "utility" test procedures. An utility test procedure is a short STOL test procedure which generally performs a limited and common function, e.g., a proc that turns on a power relay and verifies that the command executed via telemetry. The spacecraft test conductors shall develop a large number of these utility procs.

As early as possible, the spacecraft test conductors shall start developing the STOL functional test procedures required to test the observatory and its subsystems and instruments. For example, for the development of the observatory system level short form functional test; a short form functional test will be generated for each subsystem, then these test will be ordered any combined along with a period of time for instrument testing via the IGSEs. Once completed and executed the entire observatory should have been subject to a complete short form functional test.

The spacecraft test conductors shall used the same convention for naming STOL functional test procedures as used for creating the command and telemetry data bases. Guidelines for this naming convention will be specified by the TRMM I&T Manager and supplied to the spacecraft test conductors.

All STOL functional test procedures developed to reside in the SGSE to support spacecraft and observatory level testing shall contain the following elements:

- Proc Name and Title
- Purpose
- Name of preparer and editor
- Latest revision/edit date
- Use of unique sets of symbols to facilite documentation requirements (the use of ";#" at the start of each comment line that documents the procedure, an editor search option can be employed to create a document of all procs)
- Logical sequence of commands, telemetry verifications, page display calls, etc.
- Comments detailing the executing statements
- Precautions
- Manual operations

Other pertinent information for larger procs:

- Estimated run time
- Any special test configurations
- GSE required
- Outline of procedure as comment lines
- External stimulus
- Recording device requirements
- Pre turn on safe/arm plug configurations
- Post turn off configuration requirements

7.7.2.2 INSTRUMENT FUNCTIONAL TEST PROCEDURES

Instrument test procedures can either be developed and reside for execution in the SGSE or in the respective instrument IGSE (will primarily reside in the IGSE).

7.7.2.2.1 SGSE-INSTRUMENT FUNCTIONAL TEST PROCEDURES

Generally, only STOL procedures required to safe and power on/off the instruments will be created by the spacecraft test conductors to reside in the SGSE. During normal operations, all instrument testing will be performed by the instrument test conductors via the respective instrument IGSE. However, for times when the IGSE is not operating properly, the IGSE cannot communicate with the SGSE, or for some other anomalous condition where the IGSE cannot operate the instrument; a contingency mode will be employed where the SGSE is used to safe or power off the instrument. Instrument power up can only be accomplished via the SGSE.

Before the instrument arrives at GSFC and is integrated onto the observatory, any instrument test procedures required to reside in the SGSE should have been developed and verified. At a minimum this includes an instrument turn on procedure and an instrument turn off procedure. These procedures will be developed by the spacecraft test conductors with inputs from the instrument test team. (Paragraph 7.7.2.1 also applies to the development of these test procedures).

7.7.2.2.2 IGSE-INSTRUMENT FUNCTIONAL TEST PROCEDURES

Each IGSE will contain ~~automated~~ repeatable test procedures unique to the instrument it supports. All test procedures required to operate and test the instrument during the TRMM I&T effort must reside in its respective IGSE. These test procedures at a minimum might include a performance/long form functional test, a short form functional test, an aliveness test, a launch configuration and verification test, and calibration tests (see paragraphs 7.7.1.1, 7.7.1.2, 7.7.1.3, 7.7.1.4, and 7.7.1.8). All commands generated by the IGSEs during any observatory functional test will be routed through the SGSE.

All test procedures residing in the IGSE used to support its respective instrument will be developed and verified by the instrument test team. It is expected that most of these test procedures will be developed and verified before the instrument arrives at GSFC for integration, however as additional unexpected procedures are needed they can be developed by the instrument test team just prior to being executed.

7.7.2.3 STOL TEST PROCEDURES USERS MANUAL

A TRMM STOL Test Procedure Users Manual, or source listing, for the STOL test procedures shall be developed, and maintained current as new test procedures are created, by the spacecraft test conductors. The purpose of this manual is to define ; the name, title, author, version date, purpose, etc. about each STOL test procedure created and residing within the SGSE.

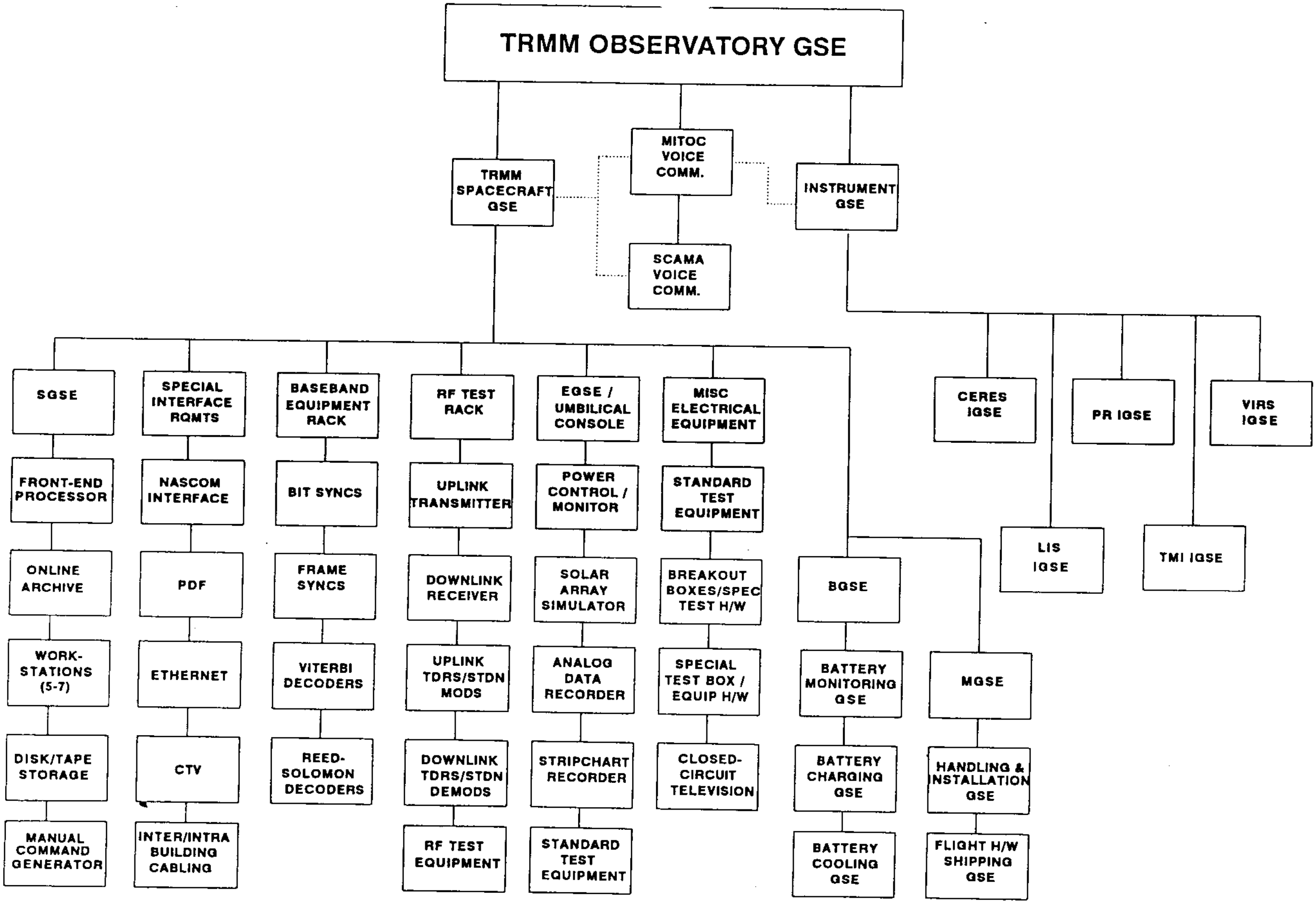


Figure 7-1 TRMM GSE FUNCTIONAL COMPONENTS

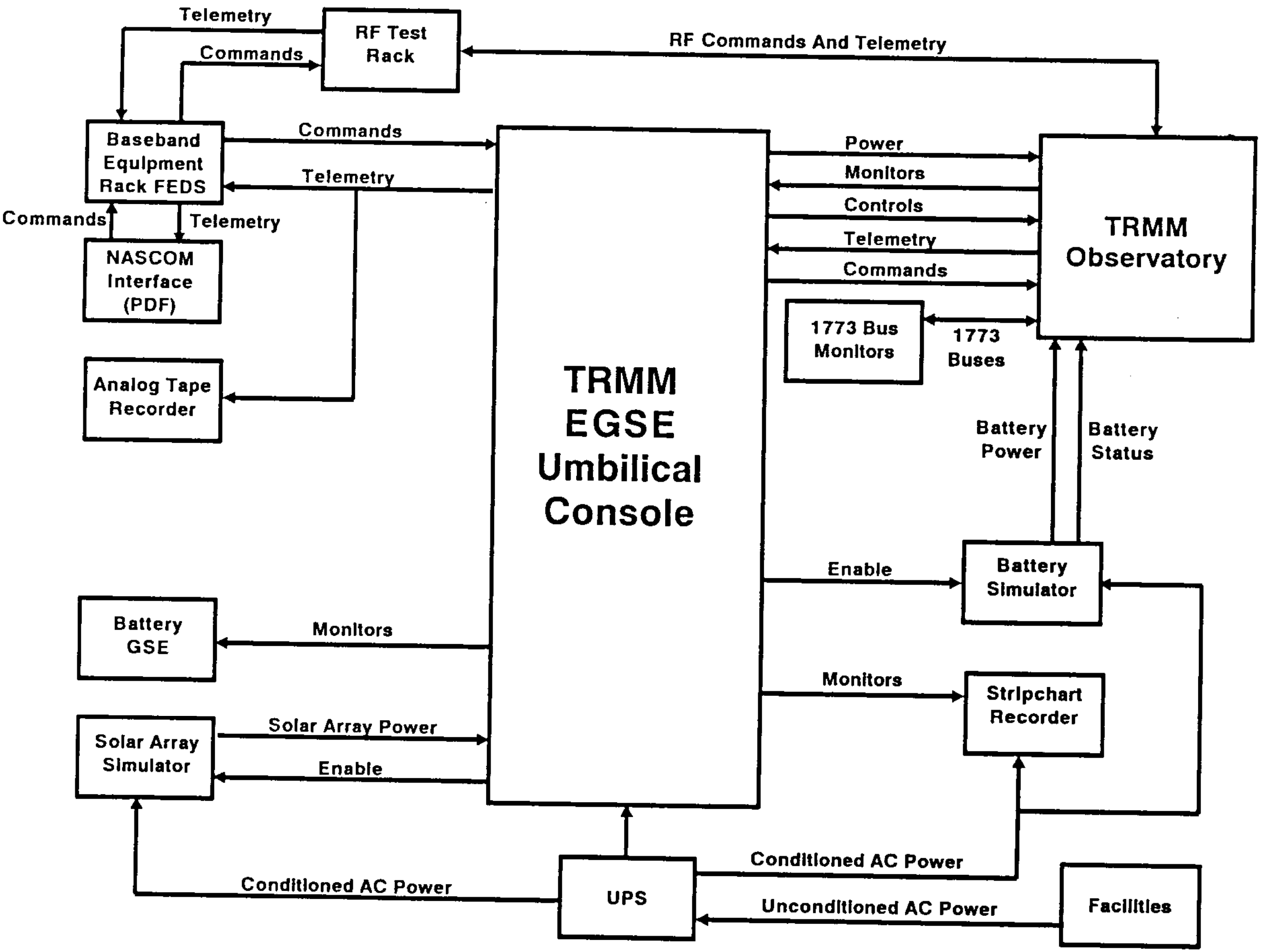


Figure 7-2 TRMM EGSE INTERFACE BLOCK DIAGRAM

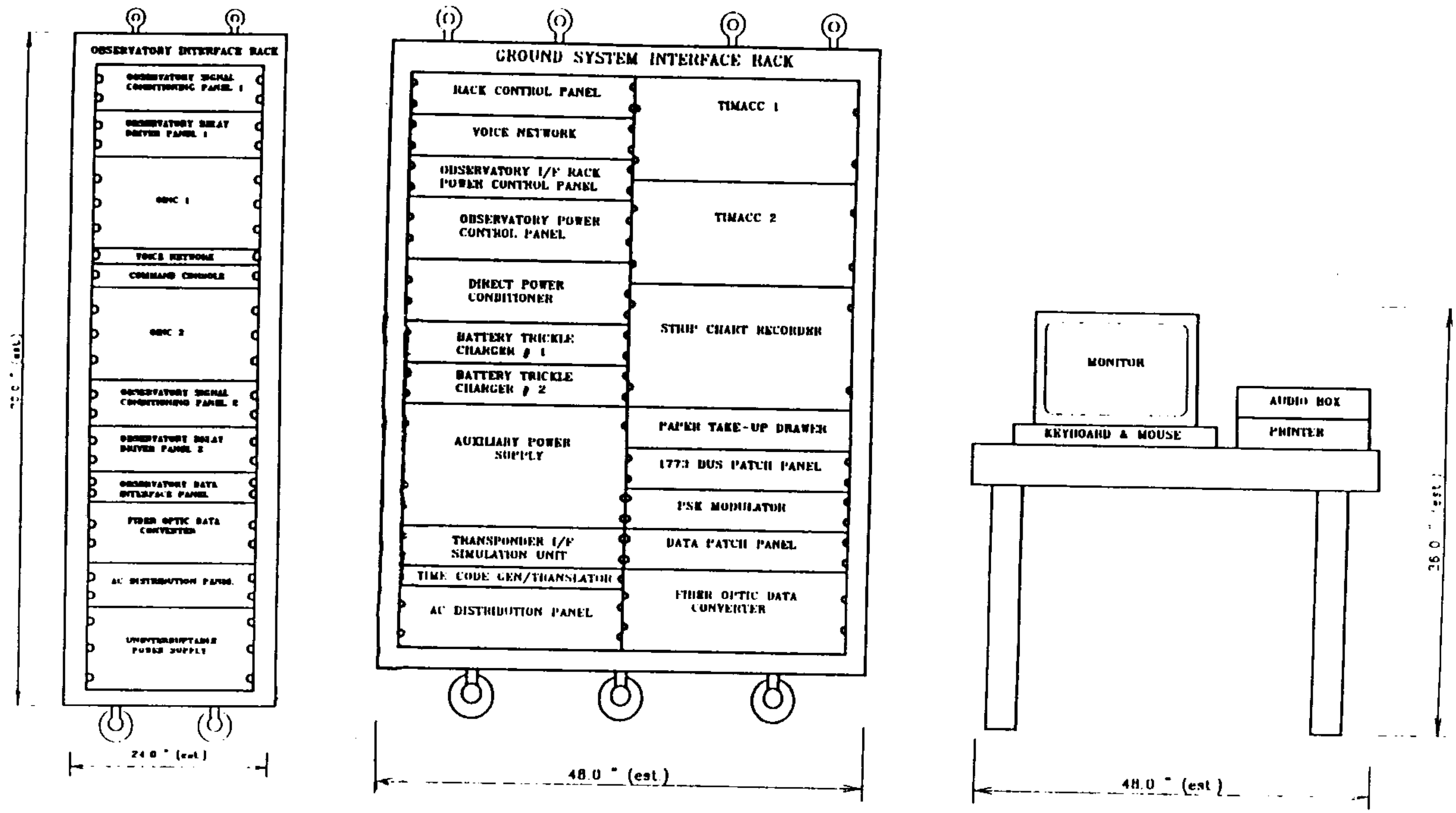


Figure 7-3 SPACECRAFT UMBILICAL CONSOLE

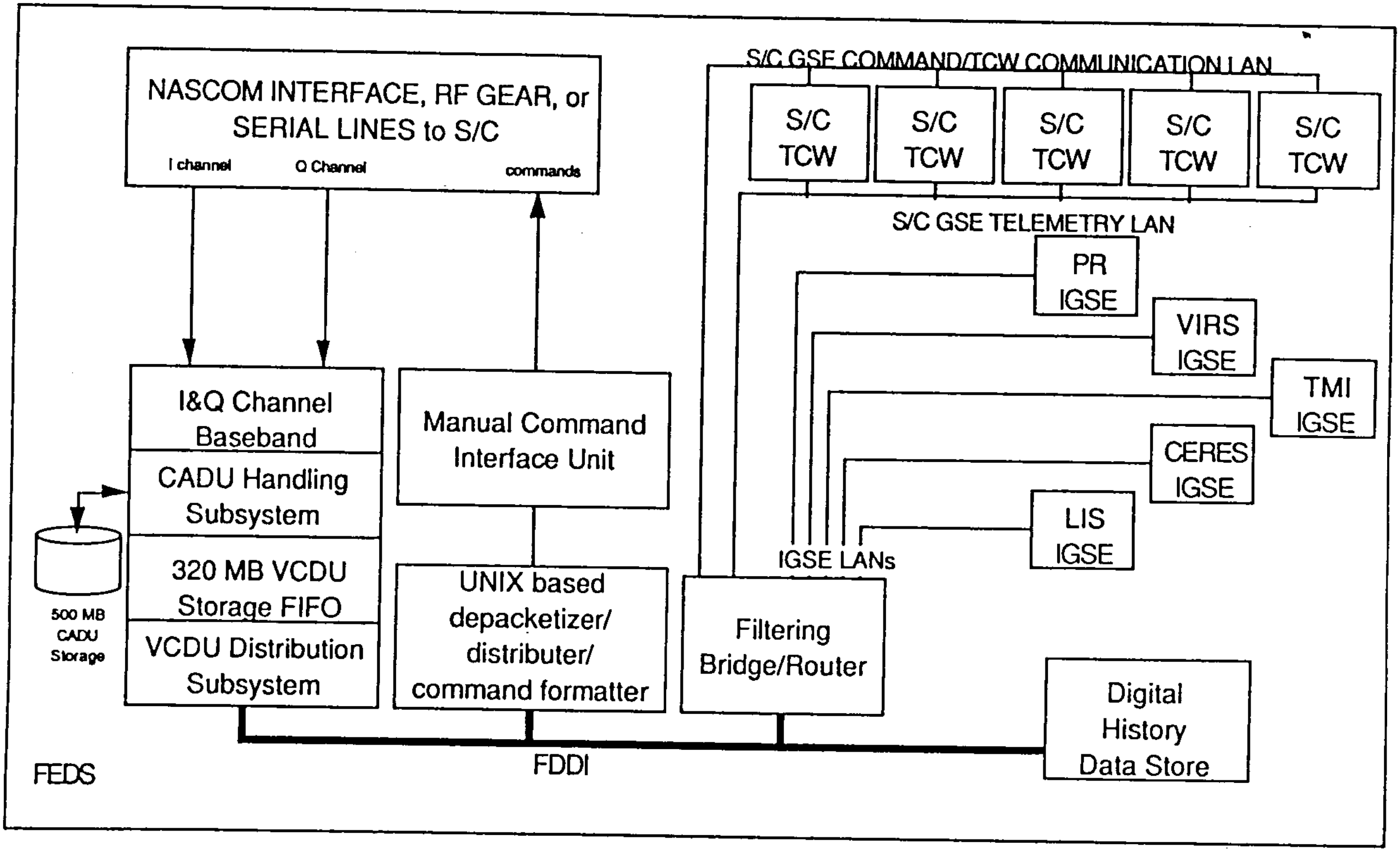


Figure 7-4 TRMM I&T COMPUTER SYSTEM

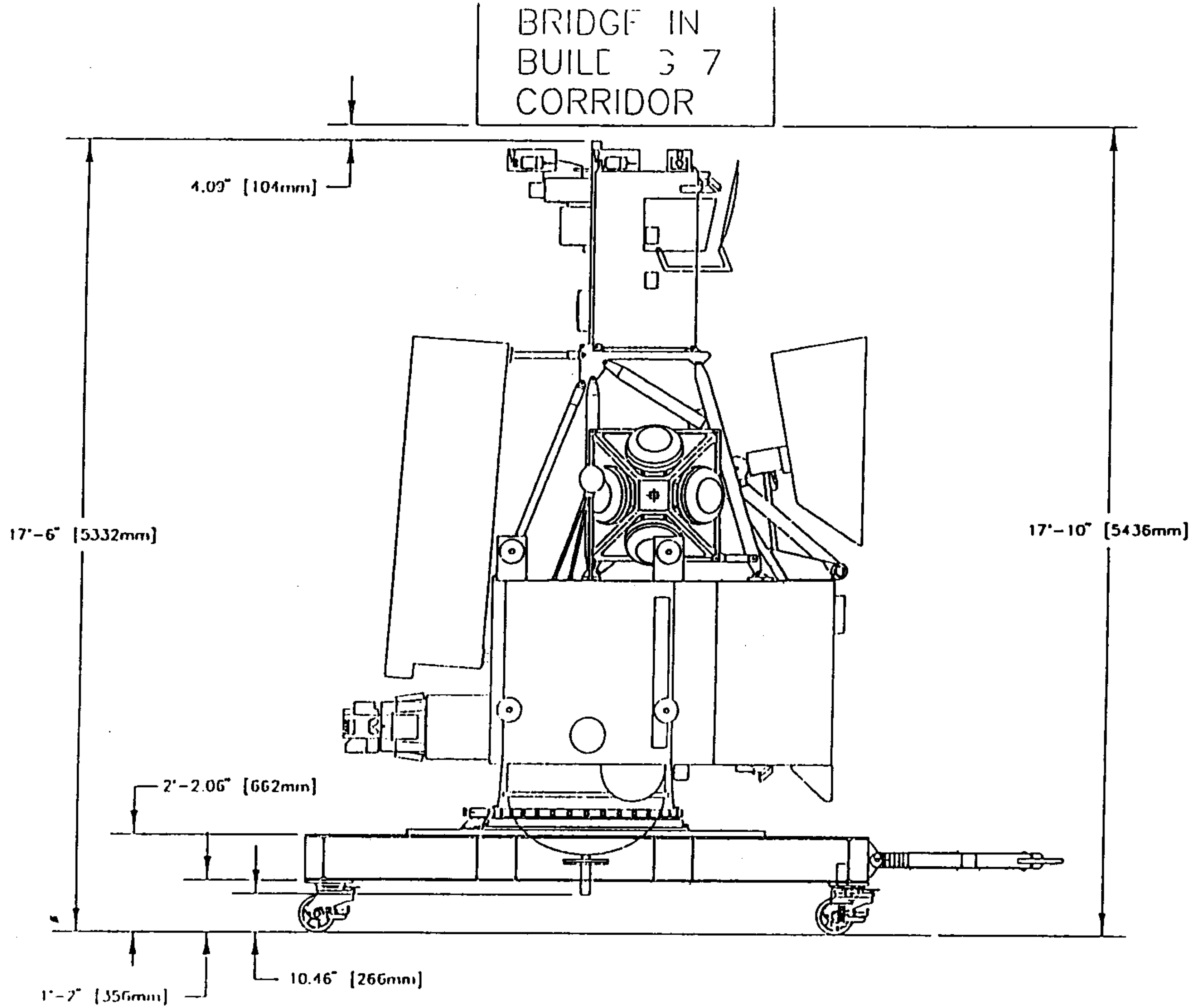


Figure 7-5 TRMM VERTICAL DOLLY

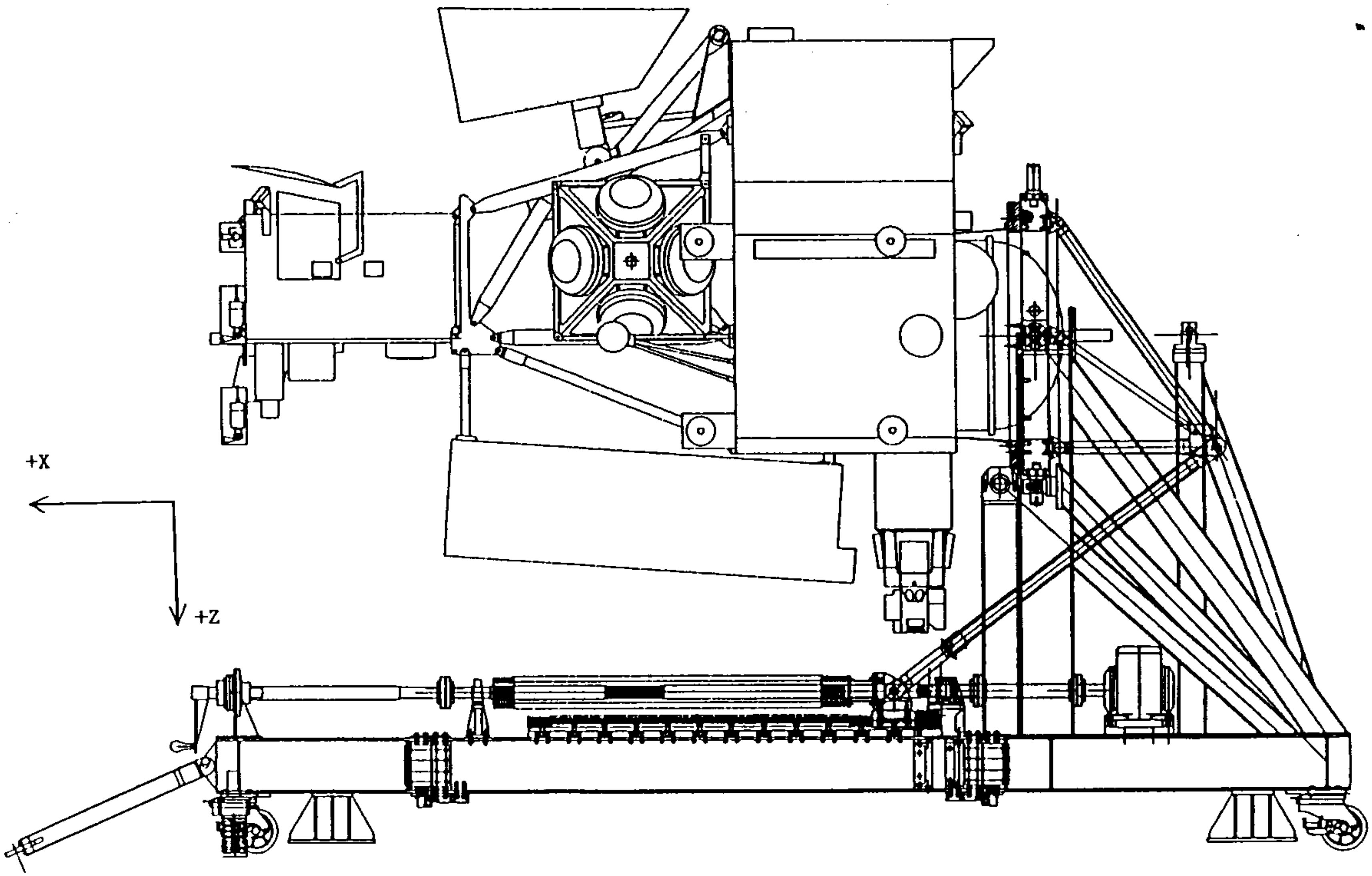


Figure 7-6 TRMM ROTATING/TRANSPORTATION DOLLY

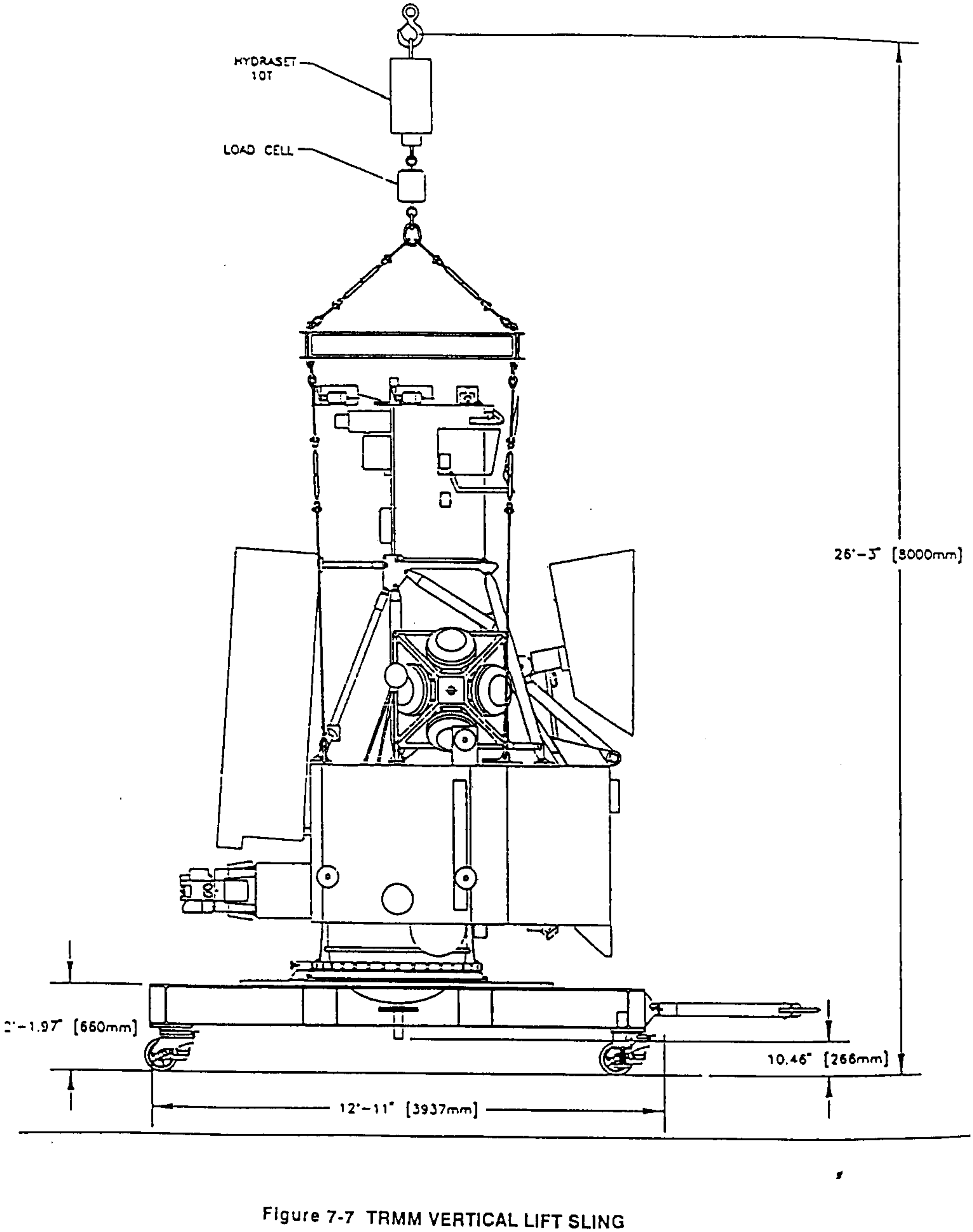


Figure 7-7 TRMM VERTICAL LIFT SLING

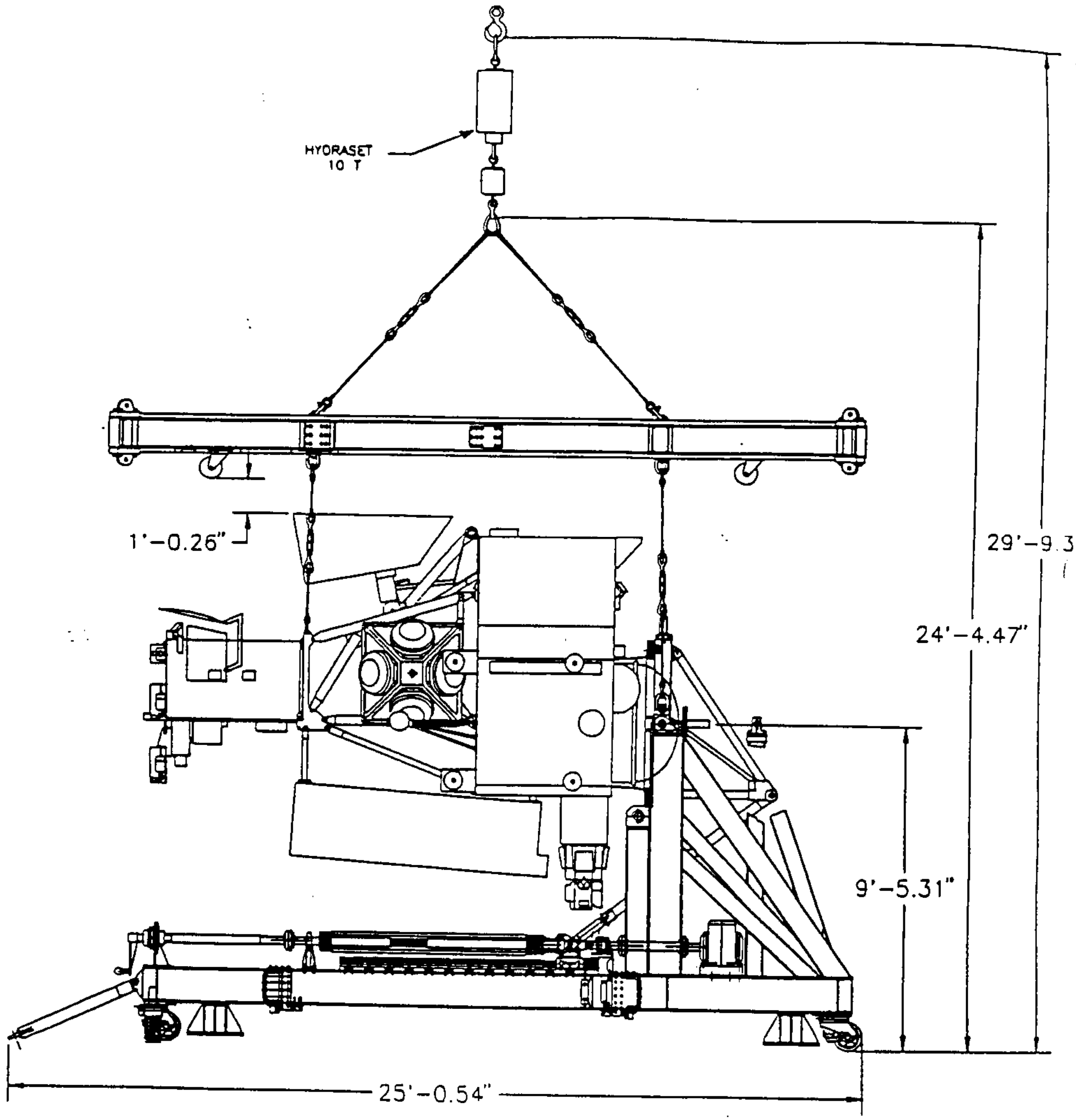
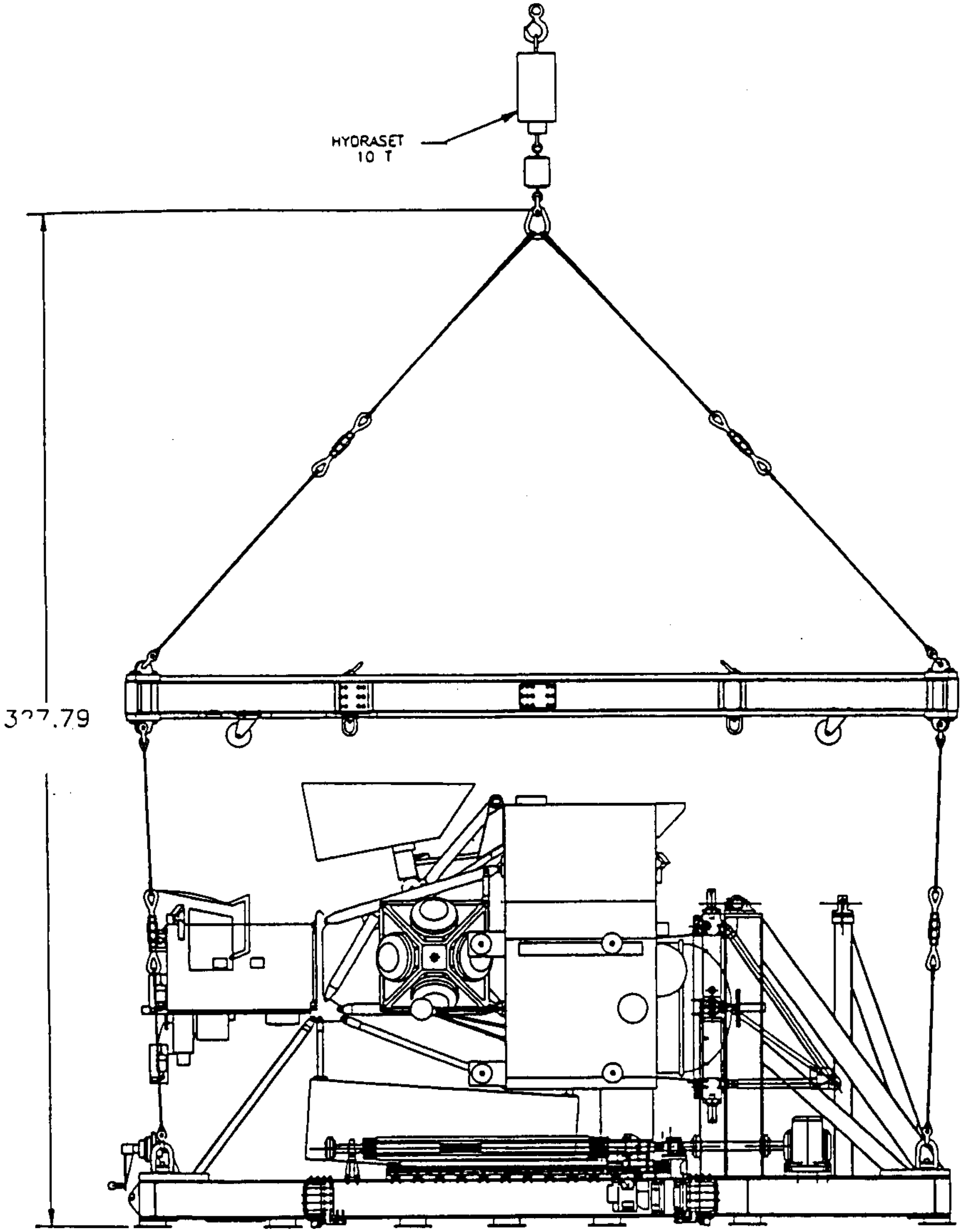


Figure 7-8 TRMM HORIZONTAL/ROTATING DOLLY LIFT SLING (OBSERVATORY CONFIGURATION)



gure 7-9 TRMM HORIZONTAL/ROTATING DOLLY LIFT SLING (DOLLY CONFIGURATION)

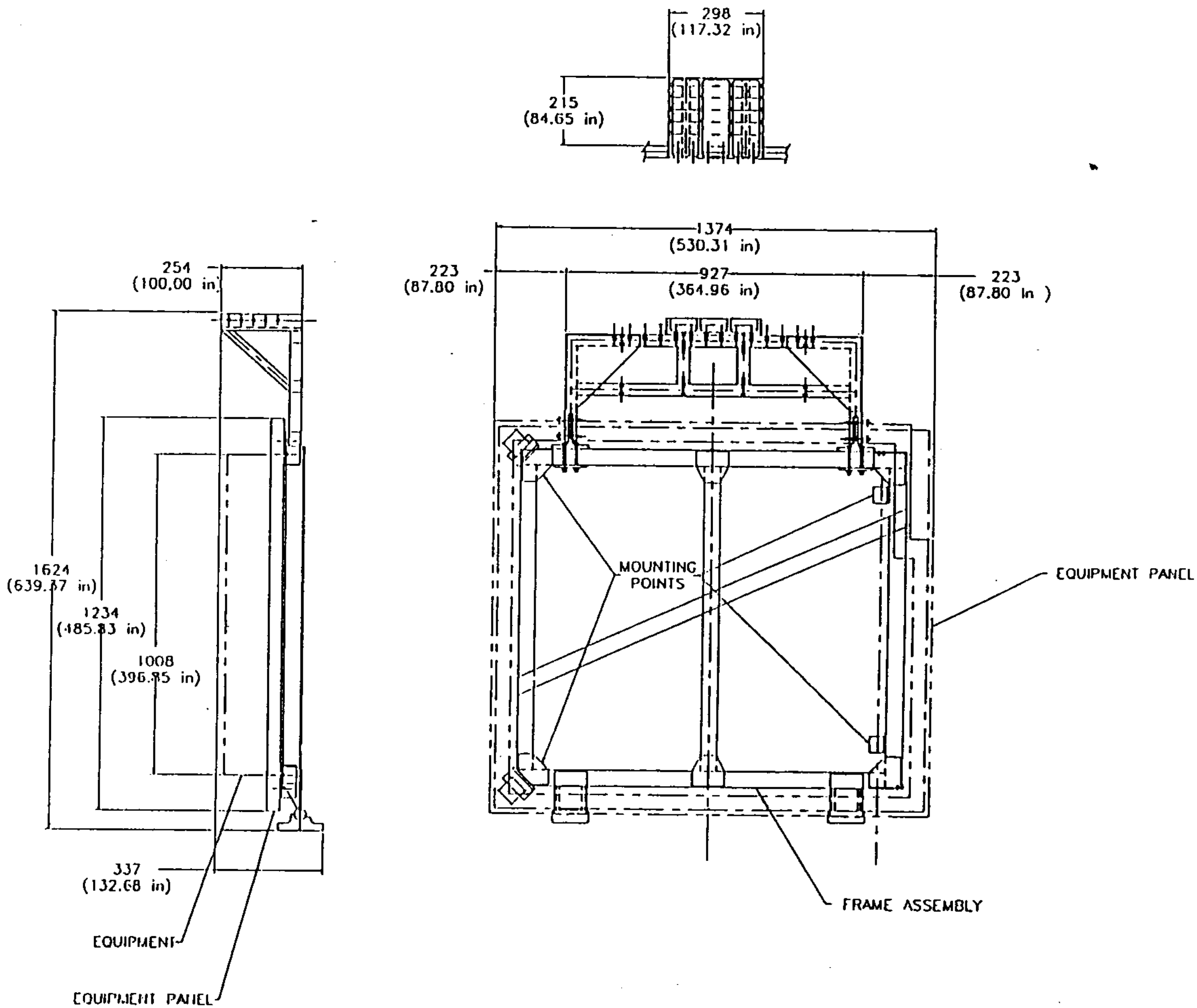


Figure 7-10 TRMM EQUIPMENT PANEL SLING/STIFFENER

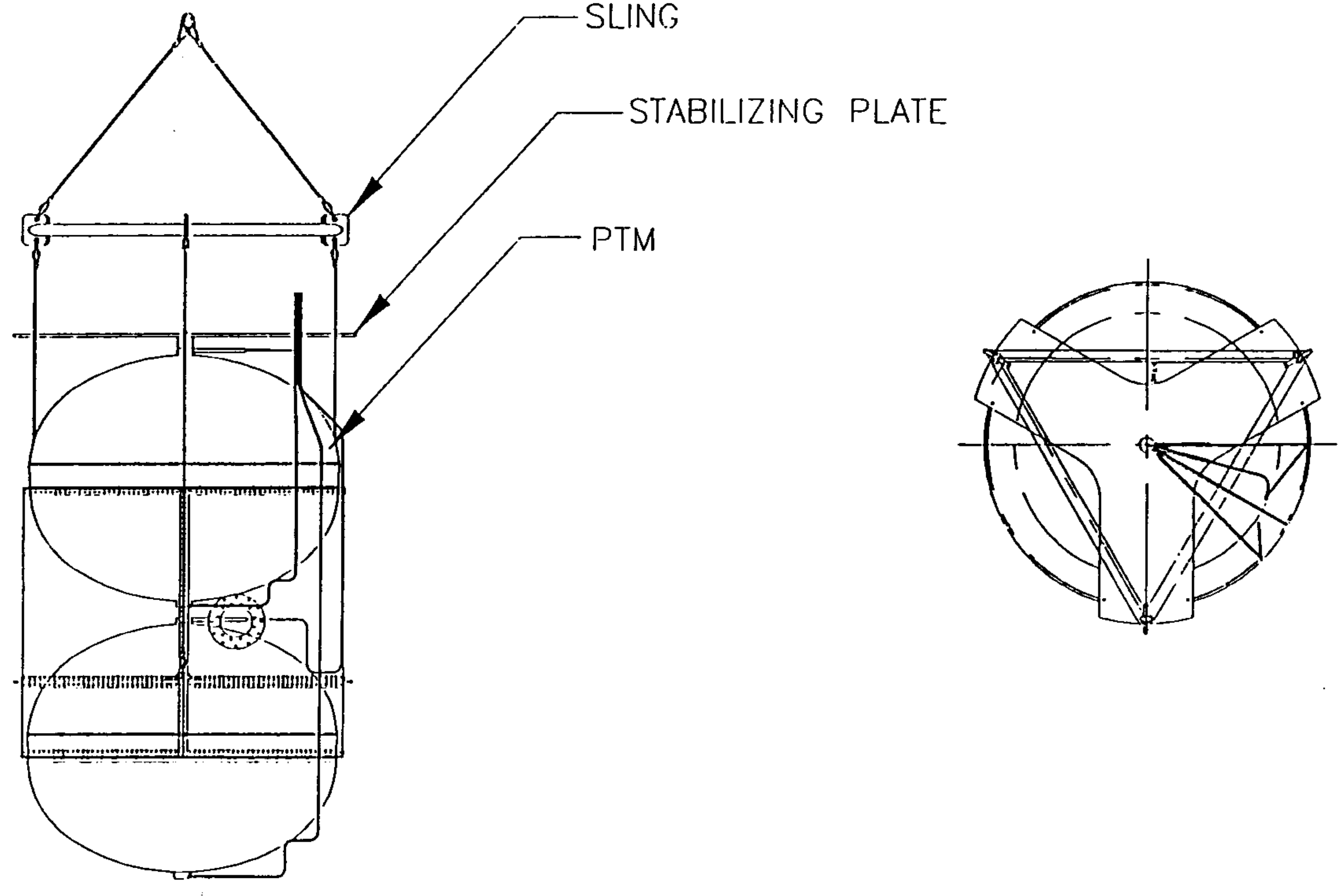


Figure 7-11 PTM LIFTING SLING

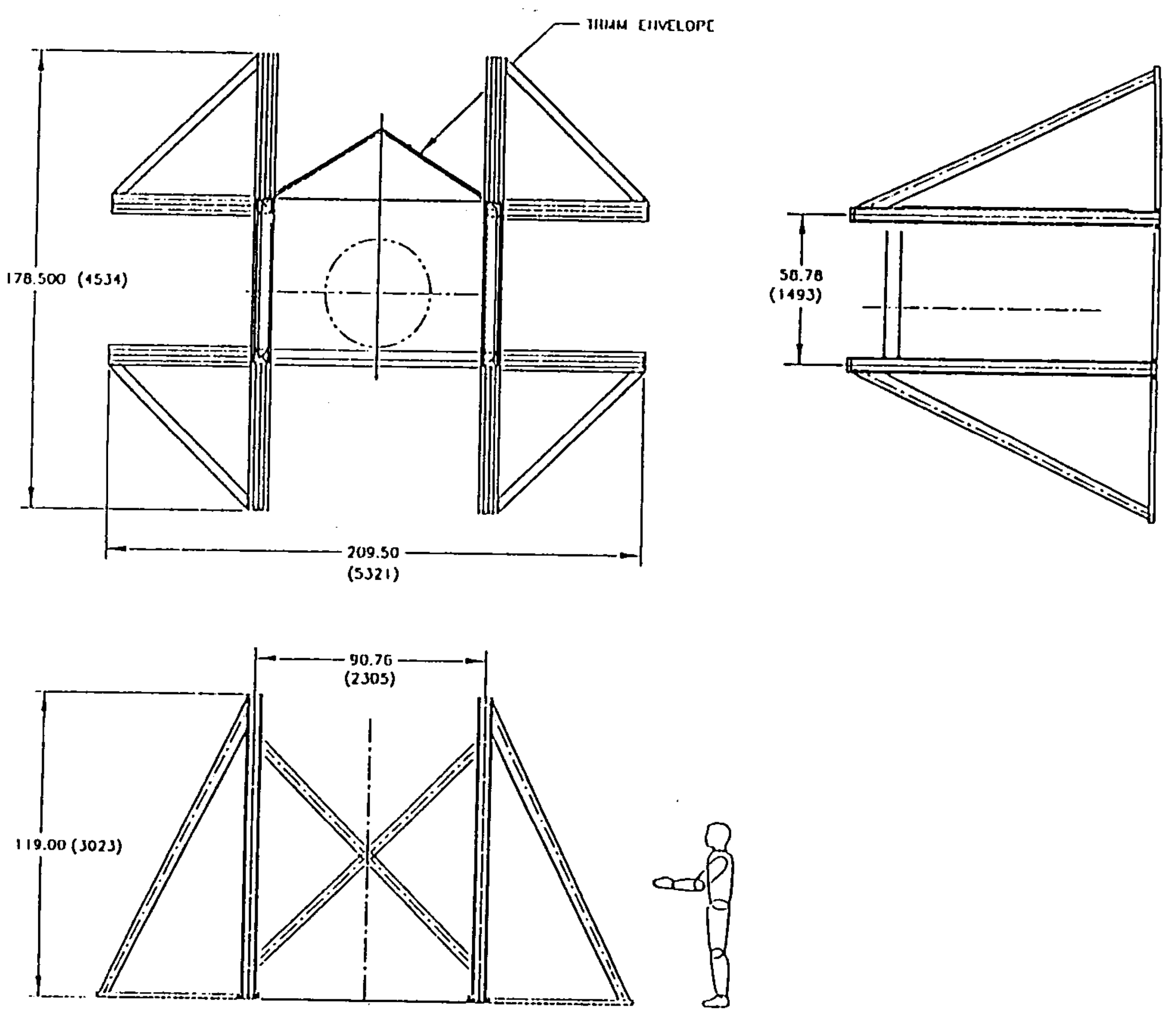


Figure 7-12 PTM INSTALLATION STAND

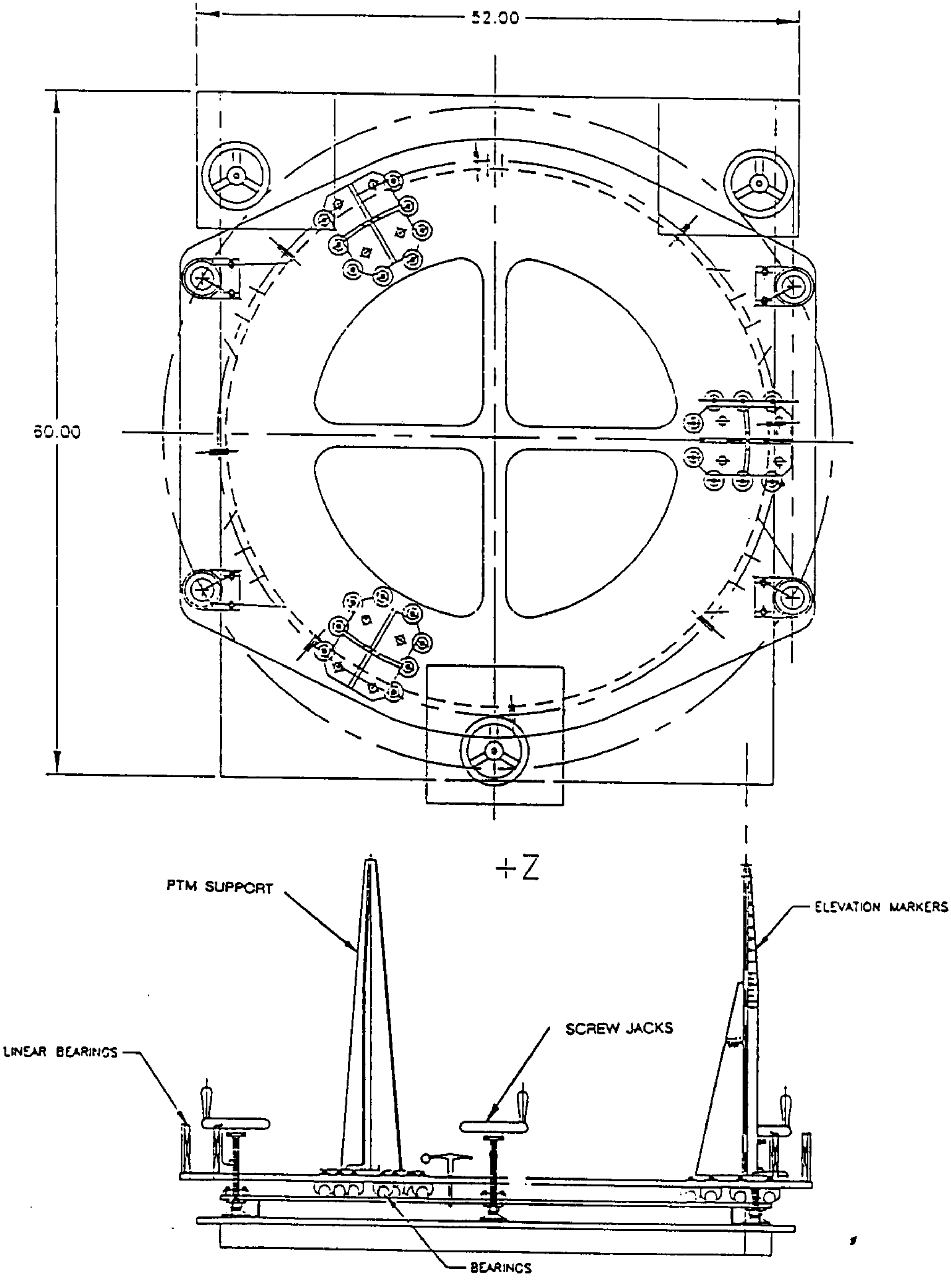


Figure 7-13 PTM FLOATING TABLE

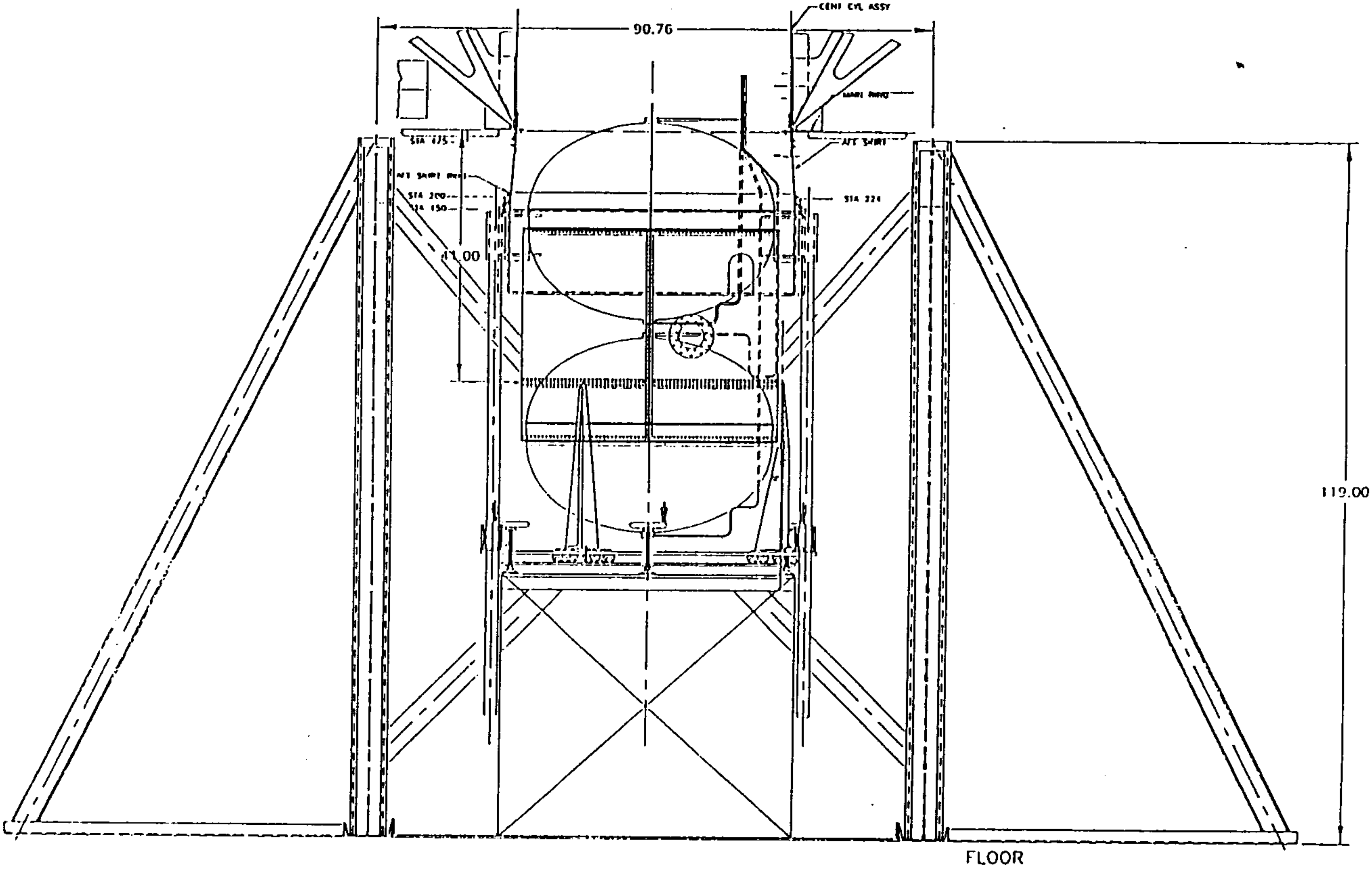


Figure 7-14 PTM INSTALLATION

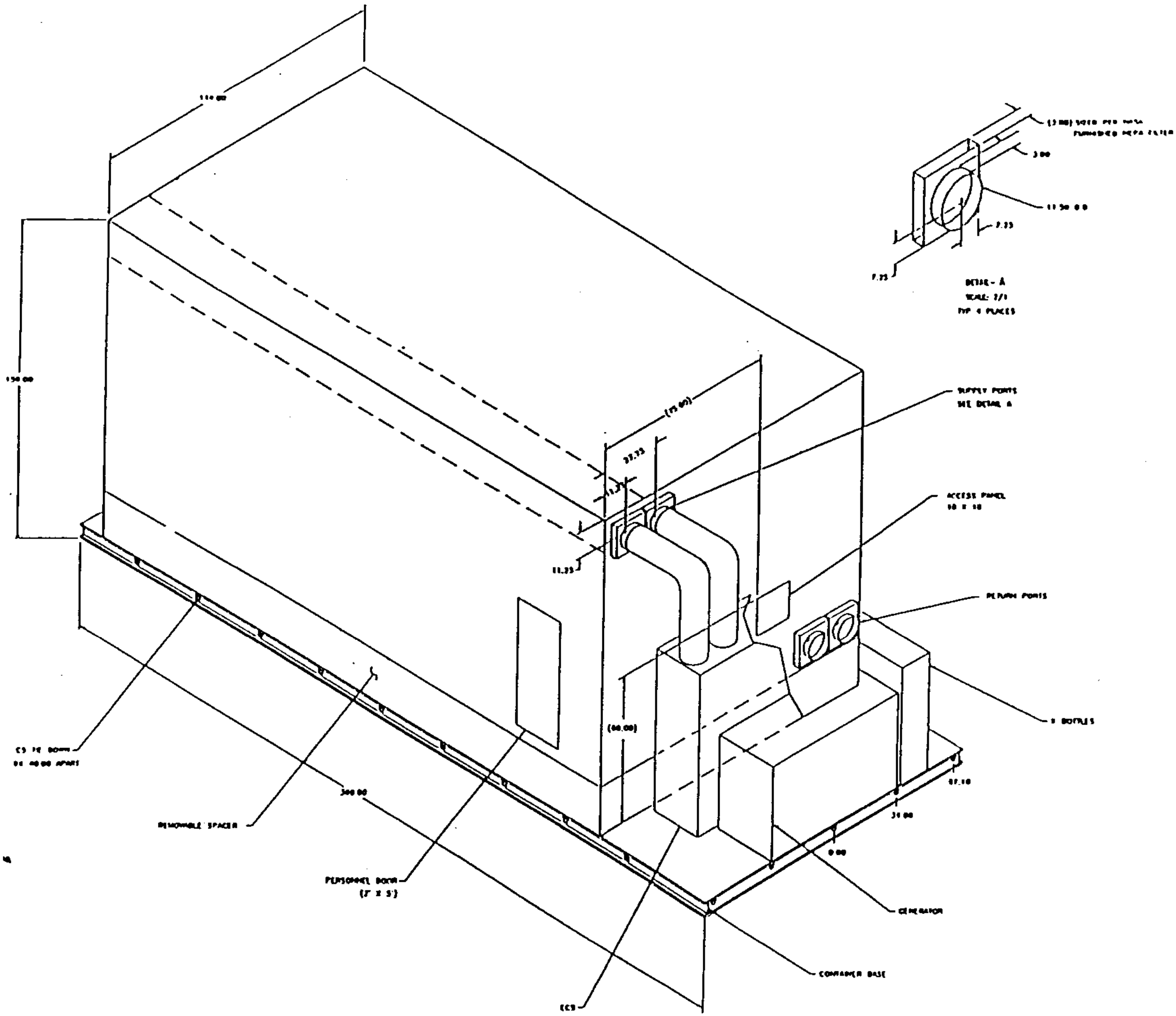


Figure 7-15 TRMM/XTE SHIPPING CONTAINER

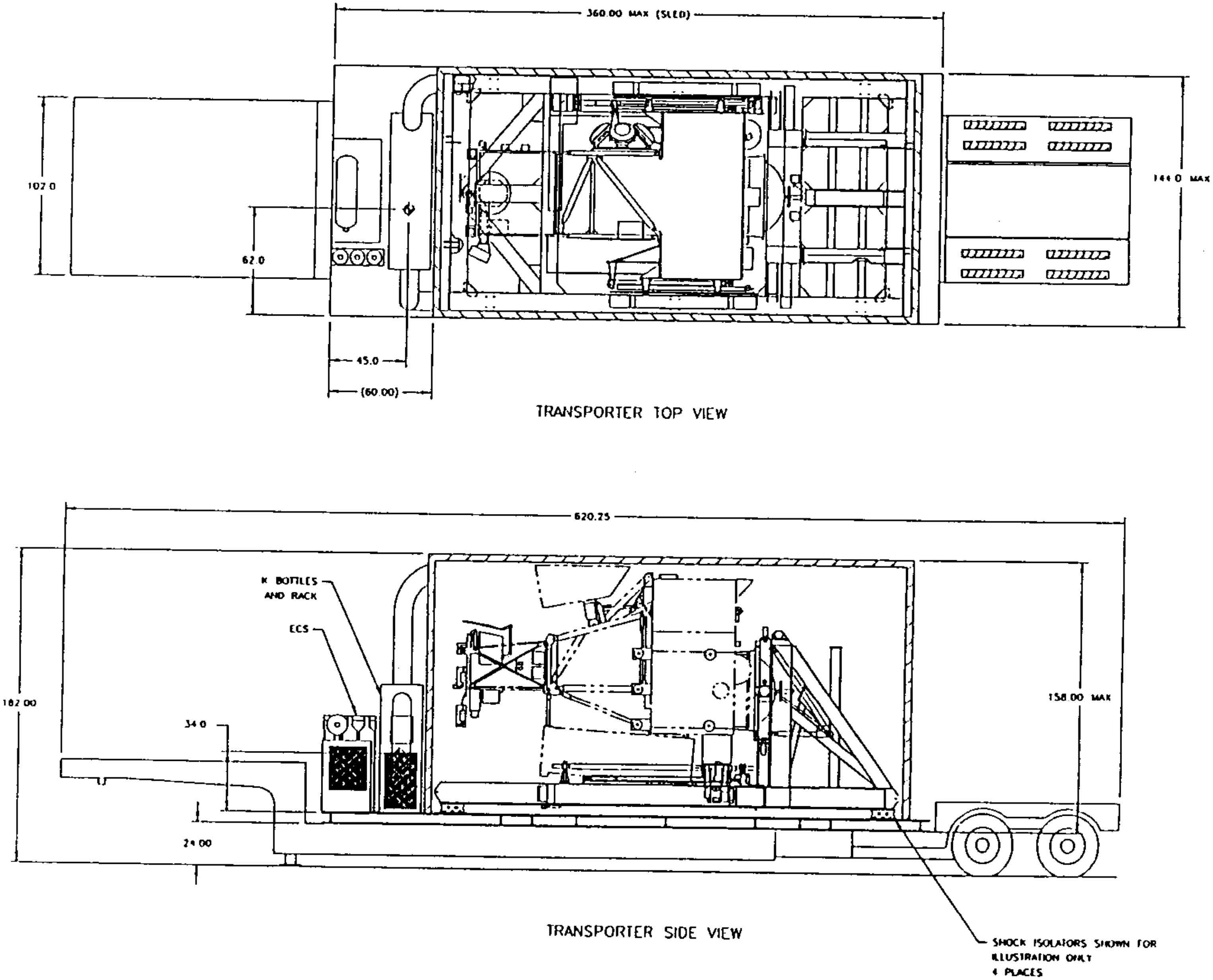


Figure 7-16 TRMM/XTE TRANSPORTER

TRMM I&T PROCEDURE TREE

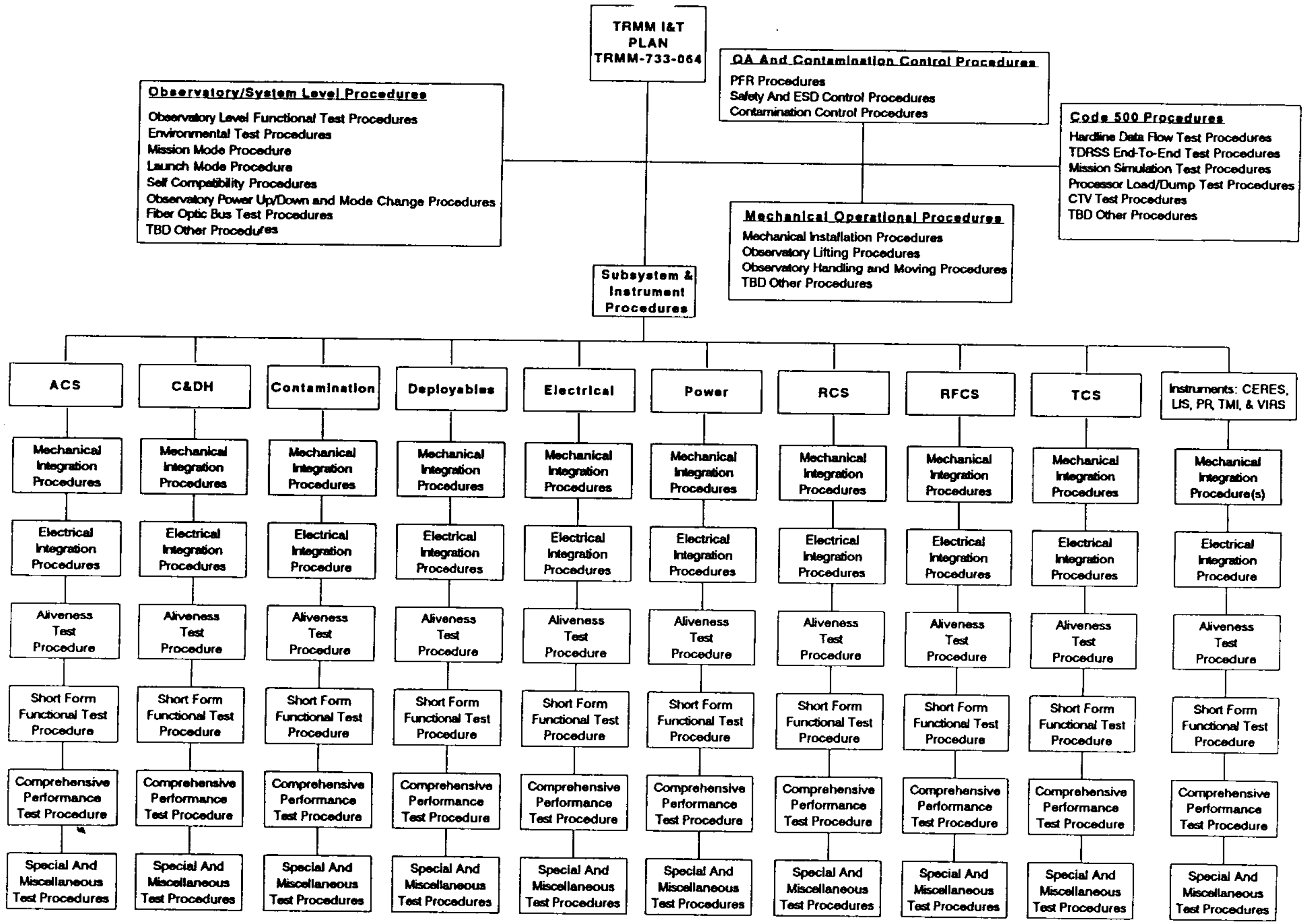


Figure 7-17 TRMM I&T PROCEDURE TREE

8.0 TRMM OBSERVATORY INTEGRATION

The purpose of this section is to outline the objectives, requirements, order of events, procedures, organizational responsibilities, and facilities required for the integration of the TRMM Observatory. Any deviations from the integration activities outlined in this document must be approved by the TRMM I&T Manager.

8.1 TRMM OBSERVATORY INTEGRATION OBJECTIVES AND REQUIREMENTS

The following are the integration objectives and requirements for the TRMM Observatory during the integration phase at GSFC. The TRMM Project Schedule Baseline Document, document TRMM-490-165 will show the proper integration sequence (see Figure 8-1, TRMM Observatory I&T Schedule, for the currently planned integration sequence at the GSFC). Also, Appendix A will show a more detailed proposed integration sequence.

a. Mechanically integrate onto the spacecraft the following flight components:

- RCS propellent tanks, thrusters, and propellant/pressurant lines
- Thermal blankets, heat pipes, louvers, and radiator panels
- Molecular Contamination Adsorber Vent
- Instrument support structure

b. Mechanically and electrically integrate the following spacecraft subsystems:

- Power
- Electrical Distribution
- Thermal Control
- RCS
- CEEM
- ACS
- RF Communications
- Deployables
- C&DH

c. Mechanically and electrically integrate the following observatory instruments:

- PR
- TMI
- VIRS
- CERES
- LIS

d. Mechanically align the following spacecraft and instrument components and assemblies:

- ACS DSS (4)
- ACS CSS (8)
- ACS IRU
- ACS ESA
- ACS TAM (2)
- ACS RWM
- ACS MTB (3)
- ACS RW (4)
- PR Instrument
- VIRS Instrument Scanner
- TMI Instrument Unit
- LIS Instrument Sensor Assembly
- CERES Instrument
- HGAD/PS (May only require a coarse alignment)
- SADDS (2) (May only require a coarse alignment)
- RCS Thruster Modules (12)

e. Using approved integration procedures, validate the spacecraft to subsystem interfaces as specified in each spacecraft to subsystem ICD.

f. Using approved integration procedures, validate the observatory to instrument interfaces as specified in each observatory to instrument ICD.

g. Verify the mechanical, electrical, and thermal compatibility at a system level, and modify as necessary to accomplish flight readiness.

h. Utilize the EGSE (includes EGSE, SGSE, BGSE, and IGSEs) and the MGSE as specified in section 7.0 of this document as a tool for observatory integration and verification operations.

i. Utilize each instrument provided IGSE, with appropriate interfaces to the SGSE, as specified in the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104 to perform the required commanding and data analysis for performance verification of each instrument.

j. Develop and verify the command and telemetry data bases for I&T, and to provide these data bases to the MOC for mission operations.

k. Develop computer based automated functional test procedures to support functional test of the observatory.

l. Functionally test all spacecraft subsystems and instruments to verify proper interface operation at both the subsystem/instrument and system levels.

m. Provide all necessary test plans, test scripts, and integration procedures, to properly integrate and checkout all spacecraft subsystems and instruments with QA signoff.

n. Document all operations with flight hardware in accordance with this document.

o. A WOA is required for each integration operation (see paragraph 4.2).

p. Maintain a safe and controlled environment.

8.2 TRMM SPACECRAFT SUBSYSTEM INTEGRATION

All spacecraft subsystems shall have been flight qualified prior to delivery to the spacecraft. Each spacecraft subsystem is comprised of various components, (see section 2.1). Prior to electrical integration of a component with the spacecraft, many of the components have never interfaced with other components within the same subsystem, or other spacecraft subsystems. Also, this will be the first time that the spacecraft subsystems will be connected to the flight harness.

8.2.1 TRMM SPACECRAFT SUBSYSTEM INTEGRATION ACTIVITY OVERVIEW

The following general integration activity scenario applies to all subsystems once delivered to the spacecraft:

a. Pre-integration activities - subsystem delivery

b. mechanical integration

c. mechanical alignment

d. electrical integration

e. subsystem functional test

f. subsystem special tests

8.2.1.1 PRE-INTEGRATION ACTIVITIES - SUBSYSTEM DELIVERY

The following pre-integration activities will be performed for each spacecraft subsystem or component of such prior to being delivered to the spacecraft for integration (see section 5.0):

a. Subsystem / subsystem component delivery to GSFC

b. Subsystem / subsystem component receiving and inspection

c. Subsystem / subsystem component acceptance test (if required)

d. Subsystem / subsystem component inspected / cleaned

e. Subsystem / subsystem component moved into SCA or SSDIF for integration or placed into project controlled bonded storage

(The TRMM I&T Manager and I&T team (other than the subsystem lead enginner and subsystem test team) are not required to support items a, b, and c. Once the subsystem, or component of such, are delivered to the project for items d. and e., the TRMM I&T Manager and I&T team involvement begins.)

8.2.1.2 MECHANICAL INTEGRATION

Once the pre-integration activities are completed (see paragraph 8.2.1.1) and the subsystem is moved into the SCA or SSDIF, the subsystem will be mechanically integrated onto the TRMM Spacecraft. The mechanical integration will be initiated by a WOA and performed per the approved mechanical integration procedure(s). (Since spacecraft subsystems are comprised of multiple components, a mechanical integration will be required for each. See Appendix A and the appropriate appendix for each respective subsystem for the planned mechanical integration order).

8.2.1.3 MECHANICAL ALIGNMENT

Upon completion of the mechanical integration, each subsystem component requiring mechanical alignment will be aligned. The mechanical alignment will be initiated by a WOA and performed per approved mechanical alignment procedures (provided by GSFC Code 717). Mechanical alignments will be verified by theodolite measurements of relative orientations of alignment cubes. All alignments will be performed with the observatory orientated in the vertical position.

8.2.1.4 ELECTRICAL INTEGRATION

Upon completion of the mechanical integration and if required mechanical alignment, the subsystem will be electrically integrated. The electrical integration will be initiated by a WOA and performed per the approved electrical integration procedure(s). (Since spacecraft subsystems are comprised of multiple components, an electrical integration will be required for each. See Appendix A and the appropriate appendix for each respective subsystem for the planned electrical integration order).

8.2.1.5 SUBSYSTEM FUNCTIONAL TEST

Upon completion of the electrical integration of a spacecraft subsystem, the subsystem test team, with support from the spacecraft test conductors, will perform a subsystem functional test (i.e., short or long form functional test). The purpose of this test is to verify that the subsystem has been properly electrically integrated and is operating nominally. At the conclusion of this test and any other required initial testing (see paragraph 8.2.1.6), the spacecraft subsystem shall now be prepared to support the electrical integration of other spacecraft subsystems (if required) and for the start of the observatory level environmental test program.

8.2.1.6 SUBSYSTEM SPECIAL TESTS

As part of the post electrical integration testing (see paragraph 8.2.1.5), any required special test should be performed to verify that the subsystem has been properly electrically integrated, that it is operating nominally, and is ready for the start of the observatory level environmental test program.

8.2.2 SUBSYSTEM INTEGRATION SUPPORT PERSONNEL AND RESPONSIBILITIES

Various personnel are required to actively support the subsystem integration activities described throughout this document. This support requires the following personnel:

- Subsystem Lead Engineer
- Subsystem Test Team
- Spacecraft Test Conductors
- Mechanical Personnel
- Mechanical Alignment Personnel
- Electrical Technicians
- QA Personnel
- Contamination Control Personnel
- Other Personnel

(See section 4.6.2 for general responsibilities and staffing requirements for the personnel required (listed above) to support the subsystem integration activities described throughout this section).

8.2.2.1 SUBSYSTEM LEAD ENGINEER

The subsystem lead engineer is ultimately responsible for being in charge of their respective subsystem.

The subsystem lead engineer shall coordinate and oversee all aspects of the subsystem pre-integration activity (see paragraph 8.2.1.1). This activity starts once the subsystem is delivered to the GSFC and is completed once the subsystem is delivered to the spacecraft in the SCA or SSDIF for integration or is placed into project controlled bonded storage. This includes: overseeing the delivery of the hardware, receiving and inspecting the hardware, arranging, overseeing, and performing any required acceptance tests.

During the mechanical integration, mechanical alignment, electrical integration, and subsequent subsystem checkout and testing, the subsystem lead engineer is responsible for verifying that these tasks are satisfactorily completed per approved procedure and that the subsystem is ready for the start of the observatory environmental test program. Also, during these integration activities the subsystem lead engineer is responsible for coordinating, directing, overseeing, and supporting the subsystem test team and to verify that all work and testing performed on the subsystem is logged.

8.2.2.2 SUBSYSTEM TEST TEAM

Each spacecraft subsystem will have a subsystem test team. In general, this team is lead by the subsystem lead engineer and is comprised of anywhere between one and five other engineers working with the subsystem. The purpose of the subsystem test team is to support the subsystem lead engineer as required throughout all TRMM integration activities involving their respective subsystem.

8.2.2.3 SPACECRAFT TEST CONDUCTORS

The spacecraft test conductors are ultimately responsible for being in charge and orchestrating spacecraft and observatory power up operations. These include all electrical integrations and functional tests.

During the mechanical integration and alignment of the spacecraft subsystem the spacecraft test conductors have no responsibilities during these tasks other then to note their satisfactory completion. (The spacecraft will not be powered during these operations).

During the electrical integration of the spacecraft subsystem, a spacecraft test conductor shall be located in the SCA or SSDIF to directly support and oversee the activity and to operate the spacecraft as needed. In addition once the C&DH electrical integration is completed, a second spacecraft test conductor will be required in the I&T operations room to monitor the spacecraft status throughout the electrical integration of subsequent spacecraft subsystems.

During spacecraft subsystem checkout and initial testing, a spacecraft test conductor will be required in the I&T operations room to power up and monitor the spacecraft, to execute the STOL test procedures required to checkout and perform any required initial testing of the subsystem, and to power down the spacecraft when the subsystem testing is completed.

During the integration activities of each spacecraft subsystem, the spacecraft test conductors shall verify the subsystem command and telemetry data bases residing in the SGSE to the fullest extent possible.

No power will be applied to the spacecraft or observatory at anytime unless a spacecraft test conductor is present.

8.2.2.4 MECHANICAL PERSONNEL

Once a spacecraft subsystem, or a component of such, is delivered to the spacecraft, the mechanical I&T team is ultimately responsible for being in charge of all subsystem operations that are mechanical in nature.

During the subsystem pre-integration activity (see paragraph 8.2.1.1), the mechanical I&T team has no responsibilities.

During the mechanical integration and alignment adjustments of subsystem components, the mechanical I&T team shall be responsible for the execution of these task per approved procedures.

During the electrical integration of the subsystem, the mechanical I&T team has no responsibilities.

During spacecraft subsystem checkout and initial testing, generally the mechanical I&T team has no responsibilities (except for when the deployable subsystem performs deployment tests).

8.2.2.5 MECHANICAL ALIGNMENT PERSONNEL

During the mechanical alignment of any spacecraft subsystem which requires such, mechanical alignment personnel will be required to support the alignment of the subsystem and to verify its correct alignment.

Mechanical alignment personnel (GSFC Code 717 personnel) are not required to support any other spacecraft subsystem integration activities.

8.2.2.6 ELECTRICAL TECHNICIANS

The electrical technicians are responsible for performing all operations on the spacecraft or observatory that are electrical in nature. Also, the electrical technicians are responsible for operating and monitoring the EGSE.

During the mechanical integration and alignment of the spacecraft subsystem, the electrical technicians shall support this activity and perform any activities that are electrical in nature as specified per approved procedures. (The spacecraft will not be powered during these operations).

During the electrical integration of the spacecraft subsystem, an electrical technician shall perform all integration operations that are electrical in nature. These include mating/demating all connectors, installing/removing OBs, making electrical measurements, making harness corrections, repairs, and modifications, and etc. A second electrical technician shall operate and monitor the EGSE during this activity.

During spacecraft subsystem checkout and initial testing, the electrical technicians shall be responsible for operating and monitoring the EGSE.

8.2.2.7 QA PERSONNEL

QA personnel will witness or monitor all spacecraft subsystem integration activities, the actual level of QA involvement will be under the control of the TRMM FAM. At anytime during the subsystem integration activity, the QA representative may halt or terminate work if a concern arises for any reason (see paragraph 3.1.3). Once the concern is resolved, the QA representative may allow the work to continue.

8.2.2.8 CONTAMINATION CONTROL PERSONNEL

Contamination control personnel are responsible for ensuring that all aspects of the TRMM Contamination Control Plan, document TRMM-732-016, are followed and maintained, and that other I&T personnel follow the same.

During the spacecraft subsystem pre-integration activity (see paragraph 8.2.1.1), contamination control personnel will be responsible for inspecting all spacecraft subsystem components for cleanliness, to clean each component if required, and to deliver the clean component to the SCA or SSDIF for integration onto the TRMM Spacecraft.

Once the spacecraft subsystem is delivered to the SCA or SSDIF for mechanical integration and all other I&T activities, contamination control personnel will be responsible for the cleanliness of the subsystem and the spacecraft as a whole.

8.2.2.9 OTHER PERSONNEL

Throughout the spacecraft subsystem integration activities described in this section, various groups of other personnel may be required to support this effort. These groups might consist of I&T and project management, review teams, etc. These groups will be called to support spacecraft subsystem integration activities as the need arises.

8.2.3 SUBSYSTEM INTEGRATION AND FUNCTIONAL TEST PROCEDURES

In order to support the spacecraft subsystem integration activities described throughout this section, various subsystem integration and functional test procedures are required. These procedures include the following:

- Subsystem Acceptance Test Procedure
- Subsystem Mechanical Integration Procedures
- Subsystem Mechanical Alignment Procedures
- Subsystem Electrical Integration Procedures
- Subsystem Checkout and Initial Test Procedures

8.2.3.1 SUBSYSTEM ACCEPTANCE TEST PROCEDURES

As part of the subsystem pre-integration activities (see section 5.0 and paragraph 8.2.1.1), if any acceptance tests are required to be performed, subsystem acceptance test procedures will be needed. These test procedures and their execution shall be the responsibility of the subsystem test team. The TRMM I&T team has no responsibilities in this area.

8.2.3.2 SUBSYSTEM MECHANICAL INTEGRATION PROCEDURES

Once the spacecraft subsystem or a component of such is delivered to the SCA or SSDIF, it will be mechanically integrated onto the TRMM Observatory (see paragraph 8.2.1.2). This will require a mechanical integration procedure (see section 7.6.1). (A mechanical integration procedure will be required for each separate subsystem component).

8.2.3.3 SUBSYSTEM MECHANICAL ALIGNMENT PROCEDURES

Once the spacecraft subsystem or a component of such has been mechanically integrated onto the TRMM Spacecraft, if required, it will be mechanically aligned (see paragraph 8.2.1.3). This will require a mechanical alignment procedure. This procedure shall be provided and executed by GSFC Code 717, (any hardware alignment adjustments will be performed by GSFC Code 722). (If more than one subsystem component requires mechanical alignment, a separate procedure will be required for each).

8.2.3.4 SUBSYSTEM ELECTRICAL INTEGRATION PROCEDURES

Once the spacecraft subsystem or a component of such has been mechanically integrated and if required mechanically aligned, it will be electrically integrated (see paragraph 8.2.1.4). This will require an electrical integration procedure (see section 7.6.2). (An electrical integration procedure will be required for each separate subsystem component).

8.2.3.5 SUBSYSTEM CHECKOUT AND INITIAL TEST PROCEDURES

Once the spacecraft subsystem has been completely and sucessfully electrically integrated, a subsystem checkout test and any special tests shall be performed (see paragraphs 8.2.1.5 and 8.2.1.6). These tests will require various STOL test procedures (see paragraph 7.7.2.1), developed by the spacecraft test conductors from inputs supplied by the subsystem test team, residing in the SGSE, and will be executed by the spacecraft test conductors under the guidance and control provided by the subsystem test team.

8.2.4 SUBSYSTEM INTEGRATION FACILITIES

(See section 6.1 for the GSFC integration facilities required by the spacecraft subsystem integration activities described throughout this section. Note that most all spacecraft subsystem integration activities with the spacecraft will be performed in the SCA with only a few being performed in the SSDIF).

8.2.5 SUBSYSTEM INTEGRATION SCHEDULE

The following is the currently planned order of integration for the TRMM Spacecraft subsystems. In general, the order cannot be revised for scheduling purposes since the general operation of a given subsystem maybe dependent on another subsystem. Sometimes the electrical integration of a subsystem must be started before another subsystem can be electrically integrated but it can not be completed until the second subsystem has been partially or completely integrated. Mechanical or other physical constraints have also been taken into consideration for determining the planned order for subsystem integration. Generally, once a subsystem, or a component of such, has been mechanically integrated it will be electrically integrated, however if warranted there may be exceptions. The TRMM Project Schedule Baseline Document, document TRMM-490-165 must reflect any changes to this plan.

a. Mechanical structure available and delivered to the project (this is a prerequisite for the start of integration)

b. RCS integration (includes 2 propellant tanks (contained in a mechanical assembly called the PTM), PCM, FDM, pressure tank, pyrotechnic valve, pressure regulator, plumbing, and thrusters; once completed the RCS will be tested (using RCS GSE) and a RCS pressure test will be performed, then moved into the SCA and cleaned)

c. Electrical harness integration (this activity includes the mechanical integration of the star couplers, installing the optical harnesses, installing and wiring the spacecraft thermistors, thermostats, and heaters; also during these activities the EGSE will be set up in parallel)

d. Initial Power Subsystem integration (includes SPRU, PBIU, PSIB, and 2 I&T batteries; only a partial electrical integration can be performed at this time, also the EGSE will be electrically integrated with the spacecraft)

e. Initial PSDU integration (includes SPSDU and IPSDU)

f. C&DH Subsystem integration (includes 2 SDS units and 2 Frequency Standards)

g. Complete Power Subsystem electrical integration

h. Complete PSDU integration (includes SPSDU and ISPDU)

i. ACS integration (includes ACE, 8 CSS's, 4 DSS's, 2 DSSE's, ESA, EVD, IRU, 3 MTB's, 4 RW's, 4 RWE's, 2 TAM's, and 2 TAME's; the RW's and RWE's are contained in a mechanical assembly called the RWM)

j. RCS electrical integration to spacecraft

k. RFCS integration (includes 2 transponders, 4 RFTS's, 2 BRF's, 2 RF power amplifiers, 2 diplexers, 2 RF terminators, 2 omnidirectional antennas, RF cables, and a RF combiner)

l. Deployables/HGAS Subsystems partial integration (includes the HGAD/PS, and the GSACE)

m. Deployables Subsystem - Solar Array Drive Assemblies (SADA) integration (2 total)

n. Molecular Contamination Adsorber Vent mechanical integration

o. HGA and TMI Instrument deployment test (requires the integration of the HGA and TMI Instrument test pyrotechnics; once the HGA deployment test is satisfactorily completed, the HGA will be integrated for testing and then removed), (note that the HGA deployment test is actually a test of the HGAD/PS, therefore the actual HGA is not required for this test)

p. De-integrate I&T batteries (2 total) and integrate qualification/test batteries (2 total)

q. CEEM integration

r. Solar array flight wing integration (2 total; also requires the integration of the SADDS test pyrotechnics)

s. Solar array deployment test (both wings)

t. De-integrate flight solar array wings (2 total) and store (after required observatory level testing is complete)

u. De-integrate qualification/test batteries (2 total) and integrate flight batteries (2 total)

v. De-integrate flight batteries (2 total) and re-integrate I&T batteries (2 total)

8.3 TRMM INSTRUMENT INTEGRATION

All instruments shall have been flight qualified prior to delivery to the GSFC for integration onto the TRMM Spacecraft. Each will have been assembled and tested at the HD facility using a HD provided "flight like" test harness, and a GSFC provided "standard" spacecraft interface simulator. The electrical integration of the instrument on the observatory will be the first time the instrument will be connected to the spacecraft flight harness. Included in each instrument integration will be an IGSE to SGSE command and telemetry interface validation. During the development phase for each instrument at the HD facility, the IGSE to SGSE interfaces will have been tested using the "standard" spacecraft interface simulator.

8.3.1 TRMM INSTRUMENT INTEGRATION ACTIVITY OVERVIEW

The following general integration activity scenario applies to all instruments once delivered to GSFC:

a. Pre-integration activities - instrument arrival

b. mechanical integration

c. mechanical alignment

d. electrical integration

e. instrument functional test in SGSE/IGSE configuration

f. instrument unique calibration or special test

8.3.1.1 PRE-INTEGRATION ACTIVITIES - INSTRUMENT ARRIVAL

The following pre-integration activities will be performed for each instrument upon arrival (see section 5.0 and the appropriate appendix for each instrument for greater detail):

a. Instrument and IGSE delivered to GSFC

b. Instrument receiving and inspection

c. Instrument acceptance test with IGSE

d. IGSE re-located to I&T operations room

e. IGSE to SGSE integration and checkout

f. Instrument moved into SCA or SSDIF for integration (this activity and the mechanical integration and mechanical alignment of the instrument can be performed concurrent with activities d. and e.), or placed into project controlled bonded storage

8.3.1.2 MECHANICAL INTEGRATION

Once the pre-integration activities are completed (see paragraph 8.3.1.1) and the instrument is moved into the SCA or SSDIF, the instrument will be mechanically integrated onto the TRMM spacecraft. The mechanical integration will be initiated by a WOA and performed per the approved mechanical integration procedure(s). (If the instrument is comprised of multiple components, see Appendix A and the appropriate appendix for each respective instrument for the planned mechanical integration order).

8.3.1.3 MECHANICAL ALIGNMENT

Upon completion of the mechanical integration, the instrument will be mechanically aligned. The mechanical alignment will be initiated by a WOA and performed per approved mechanical alignment procedures (provided by GSFC Code 717). Mechanical alignments will be verified by theodolite measurements of relative orientations of alignment cubes. All alignments will be performed with the observatory orientated in the vertical position.

8.3.1.4 ELECTRICAL INTEGRATION

Upon completion of the mechanical alignment, the instrument will be electrically integrated. The electrical integration will be initiated by a WOA and performed per the approved electrical integration procedure(s). (If the instrument is comprised of multiple components, see Appendix A and the appropriate appendix for each respective instrument for the planned electrical integration order).

The electrical integration process for each instrument along with any subsequent testing (see paragraphs 8.3.1.5 and 8.3.1.6), will provide a thorough checkout of the IGSE operation in conjunction with the SGSE.

.3.1.5 INSTRUMENT FUNCTIONAL TEST IN SGSE/IGSE CONFIGURATION

Upon completion of the electrical integration, the instrument test team will perform an instrument functional test (i.e., short or long form functional test). The purpose of this test is to verify that the instrument has been properly electrically integrated and is operating nominally. At the conclusion of this test and any other required initial testing (see paragraph 8.3.1.6), the instrument shall now be prepared for the start of the observatory level environmental test program.

8.3.1.6 INSTRUMENT UNIQUE CALIBRATION OR SPECIAL TEST

As part of the post electrical integration testing (see paragraph 8.3.1.5), any required instrument unique calibration or special test should be performed to verify that the instrument has been properly electrically integrated, that it is operating nominally, and is ready for the start of the observatory level environmental test program.

8.3.2 INSTRUMENT INTEGRATION SUPPORT PERSONNEL AND RESPONSIBILITIES

Various personnel are required to actively support the instrument integration activities described throughout this document. This support requires the following personnel:

- Instrument Manager
- Instrument Test Conductors
- Spacecraft Test Conductors
- Mechanical Personnel
- Mechanical Alignment Personnel
- Electrical Technicians
- QA Personnel
- Contamination Control Personnel
- Other Personnel

(See section 4.6.2 for general responsibilities and staffing requirements for the personnel required (listed above) to support the instrument integration activities described throughout this section).

8.3.2.1 INSTRUMENT MANAGER

The instrument manager is ultimately responsible for being in charge of their respective instrument.

The instrument manager shall coordinate and oversee all aspects of the instrument pre-integration activity (see paragraph 8.3.1.1). This activity starts once the instrument and its GSE is delivered to the GSFC and is completed once the instrument is delivered to the spacecraft in the SCA or SSDIF for integration or placed into project controlled bonded storage, and the IGSE is delivered to the I&T operations room for integration.

During the mechanical integration, mechanical alignment, electrical integration, and subsequent instrument checkout and testing, the instrument manager is responsible for verifying that these tasks are satisfactorily completed per approved procedure and that the instrument is ready for the start of the observatory environmental test program. Also, during these integration activities the instrument manager is responsible for coordinating, directing, overseeing, and supporting the instrument test team and verifying that all work and testing performed on the instrument is logged.

8.3.2.2 INSTRUMENT TEST CONDUCTORS

The instrument test conductors shall support the instrument manager during all aspects of the instrument pre-integration activity (see paragraph 8.3.1.1). This includes performing the instrument acceptance test.

Once the instrument IGSE is delivered to the I&T operations room, the instrument test conductors shall be responsible for the set up of the IGSE, and once connected to the SGSE, for performing an interface test.

During the mechanical integration and alignment of the instrument, an instrument test conductor shall be present in the SCA or SSDIF to witness this operation and to verify that it is performed per approved procedures (the instrument manager may perform this task).

During the electrical integration of the instrument, an instrument test conductor (or the instrument manager) must be present in the SCA or SSDIF to verify electrical signals and measurements and to verify that the instrument is electrically integrated per approved procedure. Also, during the electrical integration, an instrument test conductor is required in the I&T operations room to operate and control the instrument via the IGSE and to verify instrument telemetry.

During the initial instrument checkout and testing, the instrument test conductors shall be responsible for performing this testing via the IGSE, and for operating any required instrument unique test GSE in order to verify that the instrument has been properly integrated and is operationally ready for the start of the observatory environmental test program.

No power will be applied to an instrument at anytime unless a instrument test conductor or the instrument manager is present.

8.3.2.3 SPACECRAFT TEST CONDUCTORS

The spacecraft test conductors are ultimately responsible for being in charge and orchestrating spacecraft and observatory power up operations. These include all electrical integrations and functional tests.

During the mechanical integration and alignment of the instrument the spacecraft test conductors have no responsibilities during these task other then to note their satisfactory completion. (The spacecraft will not be powered during these operations).

During the integration of an IGSE with the SGSE, the spacecraft test conductors shall be responsible for supporting this effort. The spacecraft test conductors will verify that the IGSE is sending valid instrument command requests across the LAN ethernet interface to the SGSE. Also, the spacecraft test conductors will send pre recorded telemetry packets across the LAN ethernet interface to the IGSE. (The integration of the IGSE to the SGSE will be performed with the spacecraft powered off).

During the electrical integration of the instrument, a spacecraft test conductor shall be located in the SCA or SSDIF to directly support and oversee the activity and to operate the spacecraft as needed. In addition, a second spacecraft test conductor will be required in the I&T operations room to monitor the spacecraft or observatory status throughout the entire integration process.

During instrument checkout and initial testing, a spacecraft test conductor will be required in the I&T operations room to power up the spacecraft and instrument, to monitor the spacecraft and instrument, and to power down the spacecraft when the instrument testing is completed.

During the integration activities of each instrument, the spacecraft test conductors shall verify the instrument command and telemetry data bases residing in the SGSE to the fullest extent possible.

No power will be applied to the spacecraft or observatory at anytime unless a spacecraft test conductor is present.

8.3.2.4 MECHANICAL PERSONNEL

The mechanical I&T team is ultimately responsible for being in charge of all instrument operations that are mechanical in nature.

During the instrument pre-integration activity (see paragraph 8.3.1.1), the mechanical I&T team shall be responsible for all handling (including unpacking) and moving of the instrument and large pieces of GSE.

During the mechanical integration and alignment adjustements of the instrument, the mechanical I&T team shall be responsible for the execution of these task per approved procedures.

During the electrical integration of the instrument, the mechanical I&T team has no responsibilities.

During instrument checkout and initial testing, generally the mechanical I&T team has no responsibilities (except if the instruments with deployables perform deployment tests).

8.3.2.5 MECHANICAL ALIGNMENT PERSONNEL

During the mechanical alignment of the instrument, mechanical alignment personnel will be required to support the alignment of the instrument and to verify its correct alignment.

Mechanical alignment personnel (GSFC Code 717 personnel) are not required to support any other instrument integration activities.

8.3.2.6 ELECTRICAL TECHNICIANS

The electrical technicians are responsible for performing all operations on the spacecraft or observatory that are electrical in nature. Also, the electrical technicians are responsible for operating and monitoring the EGSE.

During the instrument pre-integration activity (see paragraph 8.3.1.1), the electrical technicians shall be available to support this activity as required.

During the mechanical integration and alignment of the instrument, the electrical technicians shall support this activity and perform any activities that are electrical in nature as specified per approved procedures. (The spacecraft will not be powered during these operations).

During the electrical integration of the instrument, an electrical technician shall perform all integration operations that are electrical in nature. These include mating/demating all connectors, installing/removing BOBs, making electrical measurements, making harness corrections, repairs, and modifications, and etc. A second electrical technician shall operate and monitor the EGSE during this activity.

During instrument checkout and initial testing, the electrical technicians shall be responsible for operating and monitoring the EGSE.

8.3.2.7 QA PERSONNEL

QA personnel will witness or monitor all instrument integration activities, the actual level of QA involvement will be under the control of the TRMM FAM. At anytime during the instrument integration activity, the QA representative may halt or terminate work if a concern arises for any reason (see paragraph 3.1.3). Once the concern is resolved, the QA representative may allow the work to continue.

8.3.2.8 CONTAMINATION CONTROL PERSONNEL

Contamination control personnel are responsible for ensuring that all aspects f the TRMM Contamination Control Plan, document TRMM-732-016, are followed and maintained. In addition, contamination control personnel should ensure that other I&T personnel working in TRMM cleanroom areas are responsible for following the requirements set forth in this plan.

During all instrument activities from pre-integration (see paragraph 8.3.1.1) to launch, contamination control personnel shall be responsible for monitoring and assuring cleanroom conditions and verifying the cleanliness state of the instrument. If cleaning is required, the instrument supplier contamination control or other designated representative (the project personnel) shall perform the cleaning. In general, based on past data on particulate fall-out rates in similar cleanroom facilities, instrument suppliers should make plans for several cleaning operations at the launch site.

8.3.2.9 OTHER PERSONNEL

Throughout the instrument integration activities described in this section, various groups of other personnel might be required to support this effort. These groups might consist of I&T and project management, review teams, etc. These groups will be called to support instrument integration activities as the need arises.

8.3.3 INSTRUMENT INTEGRATION AND FUNCTIONAL TEST PROCEDURES

In order to support the instrument integration activities described throughout this section, various instrument integration and functional test procedures are required. These procedures include the following:

- Instrument Acceptance Test Procedure
- Instrument Mechanical Integration Procedures
- Instrument Mechanical Alignment Procedures
- Instrument Electrical Integration Procedures
- Instrument Checkout and Initial Test Procedures

8.3.3.1 INSTRUMENT ACCEPTANCE TEST PROCEDURE

As part of the instrument pre-integration activities (see section 5.0 and paragraph 8.3.1.1) an instrument acceptance test procedure will be required to be performed. This test procedure shall be developed by the instrument test team at the instrument development site and used to test the instrument prior to delivery. This test shall reside in the IGSE for each respective instrument and will be performed at the GSFC after the instrument is delivered. The test shall be preformed by the instrument test team with the IGSE in a "stand alone" configuration.

8.3.3.2 INSTRUMENT MECHANICAL INTEGRATION PROCEDURES

Once the instrument is delivered to the SCA or SSDIF , it will be mechanically integrated onto the TRMM Observatory (see paragraph 8.3.1.2). This will require a mechanical integration procedure (see section 7.6.1). (A mechanical integration procedure will be required for each separate instrument component).

8.3.3.3 INSTRUMENT MECHANICAL ALIGNMENT PROCEDURE

Once the instrument has been mechanically integrated onto the TRMM Observatory it will be mechanically aligned (see paragraph 8.3.1.3). This will require a mechanical alignment procedure. This procedure shall be provided and executed by GSFC Code 717, (any hardware alignment adjustments will be performed by GSFC Code 722). (If more than one instrument component requires mechanical alignment, a separate procedure will be required for each).

8.3.3.4 INSTRUMENT ELECTRICAL INTEGRATION PROCEDURES

Once the instrument has been mechanically aligned, it will be electrically integrated (see paragraph 8.3.1.4). This will require an electrical integration procedure (see section 7.6.2). (An electrical integration procedure will be required for each separate instrument component).

8.3.3.5 INSTRUMENT CHECKOUT AND INITIAL TEST PROCEDURES

Once the instrument has been successfully electrically integrated, an instrument checkout test and any special tests shall be performed (see paragraphs 8.3.1.5 and 8.3.1.6). These tests will require various test procedures (see paragraph 7.7.2.2.2), developed by the instrument test team, residing in the IGSE, and to be executed by the instrument test conductors.

8.3.4 INSTRUMENT INTEGRATION FACILITIES

(See section 6.1 for the GSFC integration facilities required by the instrument integration activities described throughout this section. Note that all instrument integration activities with the observatory will be performed in the either SCA or the SSDIF).

8.3.5 INSTRUMENT INTEGRATION SCHEDULE

The following is the currently planned order of integration for the TRMM instruments. The order can be revised for scheduling purposes since the general operation of the instruments are independent of each other. At this time there have been no mechanical or other physical constraints noted that will dictate the order of instrument integration. The TRMM Project Schedule Baseline Document, document TRMM-490-165 must reflect any changes to this plan.

a. LIS instrument to observatory integration and mechanical alignment

b. VIRS instrument to observatory integration and mechanical alignment

c. TMI instrument to observatory integration and mechanical alignment

d. CERES instrument to observatory integration and mechanical alignment

e. PR instrument to observatory integration and mechanical alignment

TRMM OBSERVATORY I&T SCHEDULE

(GSFC Activities)

ACTIVITY ID	EARLY START	EARLY FINISH	ORIG DUR	ACTIVITY (1995–1997)
OBS004	3JAN95	12JAN95	8	PIM INSTALLATION INTO FLT STRUCTURE (B#29)
OBS005	13JAN95	19JAN95	4	"ROUGH" S/C CLEANING (B#29)
OBS008	20JAN95	20JAN95	1	MOVE OBS FROM B29 TO B10 BT
OBS006	23JAN95	15MAR95	37	ACS INSTALLATION & MECHANICAL INTEGRATION (BT)
OBS007	16MAR95	16MAR95	1	MOVE OBS TO PROPULSION PRESSURE TEST AREA (B#15)
OBS010	17MAR95	23MAR95	5	PROPULSION PRESSURE TEST (B#15)
OBS020	24MAR95	24MAR95	1	MOVE OBS TO B#7 SCA (B#15-7)
OBS015	27MAR95	29MAR95	3	CLEAN OBS (SCA)
OBS025	30MAR95	3MAY95	25	ELEC HARN & FOB I&T+SET-UP & INTEG EGSE (B7 SCA)
OBS030	4MAY95	17MAY95	10	INITIAL SPRU, PBIU, PSIB & I&T BATT I&T (SCA)
OBS033	18MAY95	19MAY95	2	INITIAL PSDU I&T
OBS035	22MAY95	12JUN95	15	C&DH I&T, SDS BOX/FREQUENCY STANDARDS (B#7 SCA)
OBS037	13JUN95	19JUN95	5	COMPLETE POWER SYSTEM ELEC INT (B#7 SCA)
OBS040	20JUN95	7JUL95	13	COMPLETE PSDU I&T (B#7 SCA)
OBS045	10JUL95	18AUG95	30	ACS I&T & ALIGN-ACE/EVD/SNSRS/ACTUATRS (B#7 SCA)
OBS047	21AUG95	25AUG95	5	RCS ELEC INTERFACE VERIFICATION (B7/SCA)
OBS050	28AUG95	11SEP95	10	COMMUNICATIONS I&T; CLEAN OBS (B#7 SCA)
OBS055	12SEP95	18SEP95	5	LIS INTEGRATION & ALIGNMENT (B#7 SCA)
OBS162	19SEP95	19SEP95	1	MOVE OBS TO SSOIF (B#7-29)
OBS075	20SEP95	3OCT95	10	VIRS INTEGRATION & ALIGNMENT (SSOIF)
OBS070	4OCT95	18OCT95	10	TMI INTEGRATION & ALIGNMENT (SSOIF)
OBS060	19OCT95	25OCT95	5	CERES INTEGRATION & ALIGNMENT (SSOIF)
OBS065	7NOV95	21NOV95	10	PRECIP RADAR INTEGRATION & ALIGNMENT (SSOIF)
OBS080	22NOV95	6DEC95	10	HGAS INTEG - HGADS/GSACE/GIMBAL (SSOIF)
OBS095	7DEC95	13DEC95	5	SACA I&T; CONTAMINATION CONTROL CLEANING (SSOIF)
OBS090	14DEC95	20DEC95	5	INITIAL THERMAL BLANKET TEMPLATE WORK
OBS085	21DEC95	28DEC95	5	HGA/TMI DEPLOY TEST/INST HGA & QUAL/TEST BATT'S
OBS100	29DEC95	29JAN96	20	OBS COMPREHENSIVE PERF TEST #1/CTV TEST (SSOIF)
OVT005	29DEC95	5JAN96	5	1st S/C HARD-LINE DATA FLOW
OVT010	10JAN96	10JAN96	1	1st TDRS RF END-TO-END TEST (W/ CTV)
OBS110	30JAN96	31JAN96	2	PRE-ENVIRONMENTAL TEST REVIEW (PER)
OBS112	1FEB96	1FEB96	1	MOVE OBS TO EMI/EMC TEST FACILITY (B#29-7)
OBS115	2FEB96	1MAR96	20	EMI/EMC TEST+PR/TMI/HGA RFI TESTS+CLEAN OBS (B7)
OBS117	4MAR96	4MAR96	1	MOVE OBS TO SSOIF (B#7-29)
OBS120	5MAR96	11MAR96	5	THERMAL BLANKET CLOSEOUT (SSOIF)
OBS150	12MAR96	25MAR96	10	OBS MAGNETICS SURVEY (SSOIF)
OBS300	26MAR96	26MAR96	1	FIT CHECK FLT PAF (SSOIF)
OBS125	27MAR96	27MAR96	1	CLEAN & BAG; MOVE TO THRM VAC/BAL AREA (B#29-10)
OBS130	28MAR96	8MAY96	30	OBS THERMAL VACUUM/BALANCE TEST (B#10)
OVT015	1APR96	3APR96	3	END-TO-END MISSION SIM #1
OBS140	9MAY96	30MAY96	15	COMPREHENSIVE PERFORMANCE TEST #2 (B#10)
OBS141	31MAY96	31MAY96	1	CONTAM CNTRL INSP & BAG; MOVE TO SSOIF (B#10-29)
OBS160	3JUN96	14JUN96	10	SOLAR ARRAY FLIGHT WINGS INTEGRATION (SSOIF)
OBS165	17JUN96	8JUL96	15	S/A DEPLOY SETUP & TEST+ CONT INSP & BAG (SSOIF)
OVT105	9JUL96	11JUL96	3	OBS-TO-MOC FLIGHT DATA SYSTEM TEST (SSOIF)
OBS175	12JUL96	25JUL96	10	OBS MASS PROPERTIES TEST (SSOIF)
OBS180	26JUL96	26JUL96	1	CONT CNTRL CLEAN/INSP/BAG + MOVE TO B#29-10
OBS185	29JUL96	23AUG96	20	OBS SINE-SWEEP VIBRATION TEST (B#10)
OBS195	26AUG96	30AUG96	5	ALIVENESS/SHORT FORM FUNCT TST+INSP & BAG (B#10)
OBS205	3SEP96	3SEP96	1	MOVE OBS TO ACOUSTIC TEST FACILITY (B#10)
OBS210	4SEP96	10SEP96	5	OBS ACOUSTIC TEST (B#10)
OBS211	11SEP96	17SEP96	5	ALIVENESS/SHORT FUNC TEST+CONT INSP & BAG (B#10)
OBS212	18SEP96	24SEP96	5	OBS SHOCK/PYRO FIRING TEST (B#10)
OBS215	25SEP96	27SEP96	3	ALIVENESS/SHORT FUNC TEST+CONT INSP & BAG (B#10)
OBS225	30SEP96	30SEP96	1	MOVE OBS TO SSOIF (B#10-29)
OBS235	1OCT96	3OCT96	3	REMOVE SOLAR ARRAY FLT WINGS (SSOIF)
OBS236	4OCT96	4OCT96	1	REMOVE TEST/QUAL BATTERIES FROM OBS (SSOIF)
OBS157	7OCT96	9OCT96	3	FLT BATT INTEG, TEST & REMOVAL FROM OBS (SSOIF)
OBS158	10OCT96	10OCT96	1	RE-INSTALL I&T BATTERIES (SSOIF)
OBS230	11OCT96	22OCT96	7	OBS COMPREHENSIVE PERFORMANCE TEST #3
OVT025	16OCT96	18OCT96	3	END-TO-END MISSION SIMULATION #2
OBS232	23OCT96	25OCT96	3	RCS LEAK & CALIBRATION TESTS (SSOIF)
OBS237	28OCT96	23JAN97	59	I&T SCHED CONTINGENCY
OBS238	23JAN97	23JAN97	0	OBSERVATORY I&T COMPLETE

TROPICAL RAINFALL MEASURING MISSION
DAVE AMASON - x0789
OBSERVATORY I&T SCHEDULE

Figure 8-1 TRMM OBSERVATORY I&T SCHEDULE

9.0 TRMM OBSERVATORY FUNCTIONAL TEST REQUIREMENTS

The purpose of this section is to outline the objectives, requirements, order of events, functional test procedures, organizational responsibilities, and facilities required during functional testing of the TRMM Observatory. Any deviations from the functional testing activities outlined in this document must be approved by the TRMM I&T Manager.

9.1 TRMM OBSERVATORY FUNCTIONAL TEST OBJECTIVES AND REQUIREMENTS

The following are the functional test objectives and requirements for the TRMM Observatory during the I&T phase at GSFC. The TRMM Project Schedule Baseline Document, document TRMM-490-165 will show the proper I&T sequence. Also, Appendix A will show a more detailed proposed I&T sequence.

a. Functionally test the following spacecraft subsystems before, during, and after the TRMM Observatory environmental test program:

- Power
- Electrical Distribution
- Thermal Control
- RCS
- CEEM
- ACS
- RF Communications
- Deployables
- C&DH

b. Functionally test the following observatory instruments before, during, and after the TRMM Observatory environmental test program:

- PR
- TMI
- LIS
- VIRS
- CERES

c. All performance tests shall be designed to meet the requirements of the PAR For The TRMM Mission, document TRMM-303-006, and the requirements defined in each spacecraft/instrument specification(s).

d. All testing shall be covered by an appropriate WOA (see paragraph 4.2) detailing the activity to be performed and/or referencing any approved test procedures to be executed.

e. All testing with spacecraft power applied shall be conducted in a brief and efficient manner and shall be controlled and operated in a concerted effort using the EGSE, the SGSE, and at times the appropriate IGSE's as specified in section 7.0 of this document. Testing activities shall be under the direction of the TRMM I&T Manager, with the operation of the EGSE, SGSE, and to a limited extent the IGSEs, directed by the spacecraft test conductors.

f. Utilize each instrument provided IGSE, with appropriate interfaces to the SGSE, as specified in the TRMM IGSE To SGSE Interface Control Document, document TRMM-733-104 to perform the required commanding and data analysis for performance verification of each instrument.

g. Any testing involving instruments shall be supported by the appropriate IGSE system, instrument test conductor(s), and instrument test team representative(s) as required.

h. Verify the mechanical, electrical, and thermal compatibility at a system level, and modify as necessary to accomplish flight readiness.

i. Demonstrate that the observatory can operate and survive (without failure) the conditions imposed on it by the launch and space environments.

j. Develop and verify the command and telemetry data bases for I&T, and to provide these data bases to the MOC for mission operations.

k. Develop computer based automated functional test procedures to support functional test of the observatory.

l. Functional test all spacecraft subsystems and instruments to verify proper operation at both the subsystem/instrument and system levels.

m. Provide all necessary test plans, test scripts, and test procedures, to properly integrate and checkout all spacecraft subsystem and instruments with QA signoff.

n. Determine observatory level "self" compatability

o. Determine spacecraft RF compatibility with both the Ground Network (GN) and TDRSS.

p. Determine the ability of the MOC to operate and control the observatory.

q. Document all operations with flight hardware in accordance with this document.

r. Provide photographic and/or videotape recordings per paragraph 4.1.11.

s. Maintain a safe and controlled environment.

9.2 OBSERVATORY SYSTEM LEVEL FUNCTIONAL TESTING

Observatory system level functional testing commences when the total observatory is integrated (with a few exceptions, i.e., the solar arrays, the flight batteries, etc.). Due to the unforeseen or unavoidable delivery schedule of some flight components, initial system level functional tests may be performed without these components, or if possible, with a flight-like engineering unit or "qual" model in its place.

All TRMM electronic flight hardware will be functional tested. This testing can be categorized as either pre-system functional level testing or as system level functional testing. The purpose of this section is to define and describe the differences between these two distinct types of functional testing.

9.2.1 PRE-SYSTEM LEVEL FUNCTIONAL TESTING

Pre-system level functional testing consists of the functional testing performed on any spacecraft subsystem or instrument prior to the completion of the observatory integration phase. This includes any acceptance testing performed prior to integration or any post integration testing.

9.2.1.1 ACCEPTANCE TESTING

Before spacecraft subsystem components and instruments are integrated onto the TRMM Observatory they will have been subject to various amounts and forms of acceptance tests. However comprehensive these tests are, they are not system level tests since these subsystem components or instruments are not tested with the observatory as a whole but only in a stand-alone fashion.

9.2.1.2 POST INTEGRATION TESTING

After the successful completion of the electrical integration of each spacecraft subsystem or instrument with the TRMM Observatory, functional testing will be performed for that subsystem or instrument. The purpose of this testing is to perform an initial checkout of the hardware and to verify that it has been integrated properly. Although the subsystem or instrument nterfaces directly with other spacecraft subsystems and is dependent on them or their operation, the main purpose of this testing is not to access the performance of the entire observatory since the observatory has not been completely integrated to form a complete system.

9.2.2 SYSTEM LEVEL FUNCTIONAL TESTING

Once the observatory is completely integrated it becomes a complete system. Although the spacecraft subsystems and instrument have been subject to various amounts and forms of testing on and off the observatory prior to this point they have not been tested as a complete system. Each subsystem or instrument might have performed flawlessly during previous stand-alone testing but might perform somewhat less than flawlessly when operating as part of a complete system. This is one reason why functional testing is performed on a system level, to see if the observatory is compatible with itself as a whole. In addition, the entire observatory is subject to various external environmental conditions to access and characterize its performance as a whole and to verify that it meets its overall observatory level performance requirements.

(Throughout the remaining portion of this section any reference to functional testing will refer to system level functional testing since it is assumed that the observatory, for all practical purposes, has been completely integrated by this point).

9.3 FUNCTIONAL TESTS AND PROCEDURES

Various functional test procedures will be required throughout the observatory level testing program to fully test the TRMM Observatory. For the purpose of this section, these tests will be categorized into two types; complete observatory level functional tests, and special function or purpose functional tests.

Complete observatory level functional tests include the observatory level performance functional test (also referred to as the observatory level long form functional test), the observatory level short form functional test, and the observatory level aliveness test. These tests when executed will test, to various degrees, all subsystems and instrument on the observatory, including both "prime" and "redundant" systems.

Special function or purpose functional tests include, a launch configuration and verification test, solar array and antenna boom deployment tests, a spacecraft launch sequence test, spacecraft pyrotechnic circuit and initiator tests, and various miscellaneous tests. These tests when executed will test a special function of a subsystem or instrument that is not normally tested during other testing or that requires special considerations.

(Section 7.7.1 describes the purpose all functional tests mentioned in this section. Section 7.7.2 details how these test procedures are generated and who is responsible for their development).

9.4 SUBSYSTEM FUNCTIONAL TESTING SUPPORT PERSONNEL AND RESPONSIBILITIES

Various personnel are required to actively support the subsystem functional testing activities described throughout this document. This support requires the following personnel:

- Subsystem Lead Engineer
- Subsystem Test Team
- Spacecraft Test Conductors
- Mechanical Personnel
- Electrical Technicians
- QA Personnel
- Contamination Control Personnel
- Other Personnel

This section will focus on personnel required to support subsystem functional testing, and their responsibilities, once the observatory system level functional testing commences as defined in section 9.2. (See section 8.2.2 for these requirements and responsibilities for any pre-system level functional testing as defined in section 9.2.1).

(See section 4.6.2 for general responsibilities and staffing requirements for the personnel required (listed above) to support the subsystem functional testing activities described throughout this section).

9.4.1 SUBSYSTEM LEAD ENGINEER

The subsystem lead engineer is ultimately responsible for being in charge of their respective subsystem.

During all observatory level functional testing activities related to a given subsystem, the subsystem lead engineer is responsible for operating subsystem unique test GSE, to verify that the test procedures are properly executed, to verify that the subsystem is properly tested per their approval, that the subsystem is operating and performing nominally, and that test results are properly logged and recorded. In addition, the subsystem lead engineer is responsible for coordinating, directing, overseeing, and supporting the subsystem test team, to support the spacecraft test team (particularly the spacecraft test conductor) as required, and to communicate progress and results to the I&T Manager.

9.4.2 SUBSYSTEM TEST TEAM

Each spacecraft subsystem will have a subsystem test team. In general, this team is lead by the subsystem lead engineer and is comprised of anywhere between one to five other engineers working with the subsystem. The purpose of the subsystem test team is to support the subsystem lead engineer as required throughout all TRMM functional testing activities involving their ·espective subsystem.

9.4.3 SPACECRAFT TEST CONDUCTORS

The spacecraft test conductors are ultimately responsible for being in charge and orchestrating spacecraft and observatory power up operations. These include all observatory functional testing activities.

During observatory functional testing, the spacecraft test conductor(s) will coordinate all testing activities and personnel required to support the test. For a given observatory functional test, generally the spacecraft test conductor(s) will perform in the following manner:

- brief all required support personnel on the plan for the forthcomming testing activity
- verify that all required support personnel are on station
- direct support personnel and verify that they completed all pre-test set up activities
- verify that the observatory is in a safe configuration for power up (e.g., the umbilical ie connected, no mechanical or harness work is being performed, etc.)
- power up the observatory and configure for the start of the functional test
- execute the STOL procedures needed to perform the required test
- monitor the status and health and safety of the observatory throughout all observatory power up operations and functional testing
- to have the subsystem test team verify that their subsystem is being properly tested per their approved STOL test procedures

- to support and direct the subsystem test team during the functional testing of their subsystem as appropriate
- to have the subsystem test team verify and state the correct operation of their subsystem
- to coordinate instrument test teams for instrument testing
- to power up each of the instruments as required and hand over instrument control the respective IGSE for the start of an instrument test
- to properly log all testing, results, problems, malfunctions, etc. or to verify that they are properly logged
- to power down the observatory when all testing is complete

9.4.4 MECHANICAL PERSONNEL

Generally, mechanical personnel are not required to support observatory functional testing unless a mechanical operation is performed, e.g., a deployment test, positioning the observatory, etc.

9.4.5 ELECTRICAL TECHNICIANS

During observatory functional testing activities, before any power is applied to the spacecraft, the electrical technicians are responsible for performing any and all operations on the observatory required to be performed that are electrical in nature. Also, the electrical technicians shall operate and monitor the EGSE throughout all functional testing. Only under the direction of the spacecraft test conductor(s) shall the electrical technicians apply power to the spacecraft and remove power from the spacecraft.

9.4.6 QA PERSONNEL

QA personnel will witness or monitor all spacecraft subsystem functional testing activities, the actual level of QA involvement will be under the control of the TRMM FAM. At anytime during a functional test, the QA representative may halt or terminate testing if a concern arises for any reason (see paragraph 3.1.3). Once the concern is resolved, the QA representative may allow the testing to continue.

9.4.7 CONTAMINATION CONTROL PERSONNEL

Contamination control personnel are responsible for ensuring that all aspects of the TRMM Contamination Control Plan, document TRMM-732-016, are followed and maintained and that other I&T personnel follow the same. Throughout all observatory functional testing activities and all other I&T activities, contamination control personnel are responsible for assuring the cleanliness of the subsystem and the observatory as a whole.

9.4.8 OTHER PERSONNEL

Throughout observatory functional testing, various groups of other personnel might be required to support this effort. These groups might consist of I&T and project management, review teams, environmental test directors, various groups of GSFC Code 500 personnel, etc. These groups will be called to support observatory functional testing as the need arises.

9.5 INSTRUMENT FUNCTIONAL TESTING SUPPORT PERSONNEL AND RESPONSIBILITIES

Various personnel are required to actively support the instrument functional testing activities described throughout this document. This support requires the following personnel:

- Instrument Manager
- Instrument Test Conductors
- Spacecraft Test Conductors
- Mechanical Personnel
- Electrical Technicians
- QA Personnel
- Contamination Control Personnel
- Other Personnel

his section will focus on personnel required to support instrument functional -esting, and their responsibilities, once the observatory system level functional testing commences as defined in section 9.2. (See section 8.3.2 for these requirements and responsibilities for any pre-system level functional testing as defined in section 9.2.1).

In general, the spacecraft test conductors, mechanical personnel, the electrical technicians, QA personnel, contamination control personnel, and other personnel will be required to provide the same level of support and have the same responsibilities during instrument functional testing as during spacecraft subsystem functional testing (see section 9.4).

(See section 4.6.2 for general responsibilities and staffing requirements for the personnel required (listed above) to support the instrument functional testing activities described throughout this section).

9.5.1 INSTRUMENT MANAGER

The instrument manager is ultimately responsible for being in charge of their respective instrument.

During all observatory level functional testing activities related to a given instrument, the instrument manager is responsible for verifying that the test procedures are properly executed, that the subsystem is properly tested per their approval, that the subsystem is operating and performed nominally, and that test results are properly logged and recorded. In addition, the instrument manager is responsible for coordinating, directing, overseeing, and supporting the instrument test team, the spacecraft test team (particularly the spacecraft test conductor) as required, and to communicate progress and results to the I&T Manager.

9.5.2 INSTRUMENT TEST CONDUCTORS

The instrument test conductors shall be responsible for performing all instrument functional tests via the respective IGSE and to operate any required instrument unique test GSE in order to verify that the instrument is operating and performing nominally.

For a given instrument functional test, generally the instrument test conductor(s) should perform in the following manner:

- brief all required support personnel (particularly the spacecraft test conductor) on the plan for the forthcomming instrument testing activity
- verify that all required support personnel are on station
- direct support personnel and verify that they completed all pre-test and pre spacecraft power set up activities
- verify that the instrument is in a safe configuration for power up
- to be kept informed by the spacecraft test conductor when instrument testing can commence
- to have the spacecraft test conductor power up the instrument when all applicable parties are ready and to hand over instrument control to the respective IGSE
- execute the test procedures needed to perform the required test
- operate any required instrument unique test GSE
- monitor the status and health and safety of the instrument throughout all instrument power up operations and functional testing
- to have the instrument test team verify that their instrument is being properly tested per their approved test procedures
- to have the instrument test team verify and state the correct operation of their instrument to the instrument manager
- to properly log all testing, results, problems, malfunctions, etc. or to verify that they are properly logged
- to notified the spacecraft test conductor that the instrument is going to be powered down
- to power down the instrument when all testing is complete
- to have the spacecraft test conductor verify that the instrument has indeed been power down
- to analyze test results

9.6 OBSERVATORY FUNCTIONAL TESTING ACTIVITY OVERVIEW

The purpose of this section is to give an overview of all observatory functional testing activities planned at the GSFC. It breaks down each observatory functional testing activity defined in the TRMM Project Schedule Baseline Document, document TRMM-490-165, showing what planned testing will be performed for each activity. As noted above, this will start, for all practical purposes, after the observatory has been completely integrated. This plan is preliminary and may be revised for schedule, logistical, or other valid reasons. The TRMM Project Schedule Baseline Document, document TRMM-490-165 must reflect any general ordering changes to this plan.

a. HGA and TMI Instrument Deployment Tests
   - Observatory power up, various configuration, and power down procedures
   - Spacecraft pyrotechnic circuit and initiator test
   - Execute HGA deployment test
   - Execute TMI Instrument deployment test
   - perform HGA "range of motion" test

b. Observatory Comprehensive Performance Test #1
   - Observatory power up, various configuration, and power down procedures
   - Execute observatory level long form functional test (includes long form functional test for the spacecraft subsystems and instruments)
   - Perform observatory self-compatibility test
   - Perform RFCS compatibility testing using the CTV (full test)
   - Configure observatory and hand over to MOC for MOC hardline command and telemetry testing
   - Spacecraft launch sequencer test
   - Spacecraft pyrotechnic circuit and initiator test
   - Observatory Level Mission Mode test
   - Other TBD miscellaneous tests
   - Configure observatory and hand over to MOC for MOC RFCS compatability test via the TDRSS (CTV support required)

c. Observatory Pre-Environmental Review
   (The Observatory Pre-Environmental Review is a status review - no functional testing performed)

d. Observatory EMI/EMC Test
   - Observatory power up, various configuration, and power down procedures
   - Configure observatory to various operational modes and configurations
   - Perform Instrument/HGA Radio Frequency Interference (RFI) Test

e. Observatory Thermal Blanket Template Work and Closeout
   (No functional testing performed)

f. Observatory Magnetics Survey Test
   (Observatory not powered for magnetics survey)

g. Flight PAF Fit Check
   (Mechanical operation, no functional testing performed)

h. Observatory Thermal Balance / Vacuum Test
- Observatory power up, various configuration, and power down procedures
- Execute the observatory launch configuration and verification test (for thermal vacuum chamber pumpdown)
- Execute observatory level long form functional test (includes long form functional test for the spacecraft subsystems and instruments, will most likely be executed several times throughout test)
- Perform RFCS compatibility testing using the CTV (partial test)
- Execute observatory level short form functional test (includes short form functional test for the spacecraft subsystems and instruments, will most likely be executed several times throughout test)
- Execute observatory aliveness test (includes aliveness test for the spacecraft subsystems and instruments, will most likely be executed several times throughout test)
- Spacecraft launch sequencer test
- Spacecraft pyrotechnic circuit and initiator test
- Configure observatory and hand over to MOC for MOC readiness demonstration and mission simulation test #1 via the TDRSS (CTV support required)
- Other TBD miscellaneous test

i. Observatory Comprehensive Performance Test #2
- Observatory power up, various configuration, and power down procedures
- Execute observatory level long form functional test (includes long form functional test for the spacecraft subsystems and instruments)
- Execute observatory self-compatibility test
- Spacecraft launch sequencer test
- Spacecraft pyrotechnic circuit and initiator test
- Other TBD miscellaneous test

j. Solar Array Deployment Test
- Observatory power up, various configuration, and power down procedures
- Spacecraft pyrotechnic circuit and initiator test
- Execute -Y axis solar array wing deployment test
- Execute +Y axis solar array wing deployment test
(observatory will be powered down between deployment tests for stowing the -Y axis solar array wing, re-positioning the observatory, and installing the pyrotechnics for the +Y axis solar array wing)

k. Observatory to MOC Interface Verification Test
testing and other MOC testing
- Configure observatory and hand over to MOC for MOC memory load/dump testing for the observatory microprocessors

l. Observatory Mass Properties Test
(Mechanical operation, no functional testing performed)

m. Observatory Vibration Test
- Observatory power up, various configuration, and power down procedures
- Execute the observatory launch configuration and verification test
- perform observatory aliveness test between vibration test for each axis

n. Observatory Post Vibration Test
- Observatory power up, various configuration, and power down procedures
- Spacecraft launch sequencer test
- Spacecraft pyrotechnics circuit and initiator test
- Execute observatory level short form functional test (includes short form functional test for the spacecraft subsystems and instruments)

o. Observatory Acoustic Test
- Observatory power up, various configuration, and power down procedures
- Execute the observatory launch configuration and verification test

p. Observatory Post Acoustic Test
- Observatory power up, various configuration, and power down procedures
- Spacecraft launch sequencer test
- Spacecraft pyrotechnics circuit and initiator test
- Execute observatory level short form functional test (includes short form functional test for the spacecraft subsystems and instruments, possibly the observatory aliveness test may be executed instead)

q. Observatory Mechanical Shock Test
- Observatory power up, various configuration, and power down procedures
- Execute the observatory launch configuration and verification test
- Execute launch sequencers (all spacecraft pyrotechnics including the TMI pyrotechnic, with the exception of the RCS pyrotechnic, will be fired during this test; in addition the PAF separation pyrotechnics will be fired during this test, they are controlled and fired independent of the observatory)

r. Observatory Post Shock Test
- Observatory power up, various configuration, and power down procedures
- Spacecraft launch sequencer test
- Spacecraft pyrotechnics circuit and initiator test
- Execute observatory level short form functional test (includes short form functional test for the spacecraft subsystems and instruments, possibly the observatory aliveness test may be executed instead)

s. Flight Battery Test
- Observatory power up, various configuration, and power down procedures
- Execute battery long form functional test (or applicable sections of the power subsystem long form functional test)

t. Observatory Comprehensive Performance Test #3 / End-To-End Test
   - Observatory power up, various configuration, and power down procedures
   - Execute observatory level long form functional test (includes long form functional test for the spacecraft subsystems and instruments)
   - Spacecraft launch sequencer test
   - Spacecraft pyrotechnic circuit and initiator test
   - Other TBD miscellaneous test
   - Configure Observatory and hand over to MOC for MOC testing, includes mission readiness demonstration for all ground elements, and mission simulation test #2 via the TDRSS (requires CTV support)

u. RCS Leak And Calibration Test
   - Observatory power up, various configuration, and power down procedures
   - Execute RCS long form functional test
   - Perform RCS leak test
   - Perform RCS calibration test

9.7 OBSERVATORY FUNCTIONAL TESTING FACILITIES AND CONTROL

During the functional testing outline in paragraph 9.6 above, the observatory will be located in various test facilities throughout the GSFC building 7/10/15/29 complex. However, all observatory testing at the GSFC will be conducted or controlled from the TRMM I&T operations room. (See section 6.1 for description of test facilities and I&T operations room).

During observatory functional testing performed by the MOC, the observatory will be commanded by the MOC and telemetry will be monitored by both the MOC and the spacecraft test conductor(s) located within the I&T operations room. At any time during MOC testing, the spacecraft test conductor(s) will have the almost instant capability of resumming commanding of the observatory, therefore they are in overall control of the test. (The actual time to resume commanding of the observatory will be a few seconds. It will require a "patch" change on a patch panel located near the spacecraft test conductor(s) located in the I&T operations room.)

During compatability testing of the RFCS performed by the CTV, the observatory will remain under the control of the spacecraft test conductor(s) at all times. The observatory will be configured such that the CTV will be connected to one transponder and the EGSE will be connected to the other. This will allow the CTV to receive telemetry data via the transponder and to send forward link command signals to the same transponder. Also, this will allow the spacecraft test conductor(s) located in the I&T operations room to receive hardline telemetry from the observatory and to command the observatory through the other transponder. Therefore, the spacecraft test conductor(s) will remain in control of the observatory during this test. Once the CTV has completed testing with the transponder, the observatory will be configured similarly for CTV testing with the other transponder.

10.0 TRMM OBSERVATORY ENVIRONMENTAL TEST PROGRAM

The purpose of this section is to give an overview of the environmental test program planned for the TRMM Observatory. Its intent is to give the TRMM I&T team a prospective of what I&T activities will be performed during each environmental test and what is the purpose of each environmental test.

(For more information about the TRMM Observatory environmental test program refer to the TRMM Environmental Test Program Plan Overview, document TRMM-733-206 or the individual test plans for each environmental test).

10.1 ENVIRONMENTAL TEST PROCEDURES AND TEST ENVIRONMENTAL DIRECTORS

The various environmental tests will require a top level narrative procedure. It will contain the sequence of events to perform the test at hand, i.e. the vibration test levels, thermal vacuum temperatures, etc.

For each environmental test there will be an environmental test director representing the TRMM Project. (This environmental test director is different from the environmental test director representing GSFC Code 750 whom is responsible for the environmental test facility). The environmental test director will be a person appointed and approved by the project to direct the test. This person is usually one who is most familiar with the particular nvironmental test to be performed. This person will be responsible for .he environmental test procedure. This procedure shall specify observatory configurations, define test specifications, requirements, testing levels, etc. Also, the environmental test director will direct the execution of the test, verify that the objectives of the test are met before proceeding, and will provide coordination between the various groups involved in the test including the environmental test director for the test facility.

Guidelines For Preparing Environmental Test procedures, document X-750-93-004 shall be used by the various environmental test directors for the TRMM Project when developing environmental test plans and procedures.

10.2 ENVIRONMENTAL TESTS

Once the TRMM Observatory has been integrated and initially functionally tested, the observatory as a whole will undergo environmental testing. The following are the environmental tests planned to be performed on the TRMM Observatory.

- EMC/EMI
- Magnetics
- Thermal Balance / Thermal Vacuum
- Mass Properties
- Vibration
- Acoustics
- Mechanical Shock (due to separation and deployables)

During the environmental test program, the TRMM Observatory will be subject to all applicable requirements defined by the GEVS-SE. The TRMM PAR, document TRMM-303-006 and the GEVS-SE are the authoritative documents for the TRMM Observatory level testing. Additional requirements imposed by the launch vehicle, launch site environment, or by request of individual subsystems or instruments may be performed subject to TRMM Project approval. The TRMM Verification Plan, document TRMM-750-113 details the observatory level environmental test program.

10.2.1 EMI/EMC

EMC tests will be conducted to ensure that the TRMM Observatory does not generate EMI that will adversely affect the safety and operation of its own systems or the launch vehicle. It would also ensure that the observatory is not susceptible to EMI which it may be exposed during its mission life. The test shall be performed based on the requirements and limits specified in the TRMM Electrical Subsystem Specification, document TRMM-733-043.

For radiated and conducted emissions testing, the observatory will be powered and configured such that it is in its "noisiest" mode, as appropriate. The emissions will be measured verifying they are within specified limits.

For susceptibility testing, the observatory will be powered and configured such that it is in its its "quiet" or most sensitive mode. The observatory will then be exposed to various levels of EMI. During this testing all spacecraft subsystems and instruments shall be closely monitor by the spacecraft test conductors, subsystem I&T teams, and instrument I&T teams, looking for abnormal effects or interference caused by the test.

The environmental test director representing the project for the this test will most likely be either the Electrical Subsystem Lead Engineer, the Spacecraft Systems Engineer, or the TRMM Systems Manager.

10.2.2 MAGNETICS

A magnetics survey will be performed to determine the magnetic properties of the observatory. This test will be performed using portable magnetometers. The observatory will be configured such that all components which produce magnetic fields will be exercised, i.e., the magentic torquer bars. Not only will the magnetic field strength around the observatory be measured to determine if it is within acceptable levels, but spacecraft components which are sensitive to magnetic fields (i.e., the TAMs) will be monitored to verify that that are not adversely affected.

The environmental test director representing the project for this test might be the Spacecraft Systems Engineer, the TRMM Systems Manager, or some other applicable person appointed and approved by the TRMM Project.

10.2.3 THERMAL BALANCE / THERMAL VACUUM

A thermal balance test will be performed in vacuum to demonstrate the validity of the thermal design of the observatory. Also this test will be used to validate the thermal analytical model and the ability of the thermal control system to maintain the hardware within the established thermal limits for the TRMM mission. The predicted maximum and minimum mission temperatures will be verified using appropriate cold plates and/or heater plates to simulate the flight thermal inputs predicted by the model. The ability of the thermal control devices used to maintain predicted temperatures (i.e., thermostatically controlled heaters) will be verified. Results of the verification of the thermal model will be used to confirm thermal vacuum test levels.

A thermal vacuum test will be performed to verify proper operation of the TRMM Observatory under the conditions of simulated space vacuum, during imposed temperatures that are 10 degress Celsius more severe than the maximum and minimum predicted for the mission, and during periods of temperature transition.

During thermal vacuum, the observatory will be subject to at least four temperature cycles (eight transitions between temperature extremes with the observatory operating). The test duration will be based on the time required to complete functional testing of the observatory at each hot and cold level but there will be a minimum time at each level. Various functional tests will ɘ performed on the observatory during both cold and hot soaks. These tests ɴclude various functional tests (i.e., long form functional, short form functional), observatory turn-on test, launch configuration test for chamber pumpdown, survival and safehold test, and others.

All critical temperatures will be monitored throughout both the thermal balance and thermal vacuum tests to ensure that temperature sensitive items do not exceed allowable limits.

The environmental test director representing the project for the this test will be the Thermal Control Subsystem Lead Engineer as far as directing the Thermal aspects of the test. The overall test planning will be lead by TRMM Systems Engineering.

10.2.4 MASS PROPERTIES

Mass properties measurements will be taken on the observatory. This test will consist of a weight measurement, a center of gravity measurement in two axes (the center of gravity for the vertical axis will have to be calculated), and a MOI measurement in one axis. The observatory will remain unpowered throughout this test.

The environmental test director representing the project for the this test will most likely be the Structural Subsystem Lead Engineer.

10.2.5 VIBRATION

The TRMM Observatory will be subject to a sine sweep vibration test. The purpose of this test is to determine its resonant frequencies, to observe its behavior, and to verify the integrity and workmanship for all mechanical and electrical assembilies on the observatory. The observatory will be vibrated to specific limits, along one axis at a time, at specific frequencies. During vibration the observatory will be powered and configured in its launch configuration. For this test the observatory will be attached to the test PAF.

The environmental test director representing the project for the this test will most likely be the Structural Subsystem Lead Engineer.

10.2.6 ACOUSTICS

An acoustic noise test will be performed to demonstrate that the TRMM Observatory will perform without degradation when exposed to an acoustic environment representative of that encountered during launch. During the acoustic test the observatory will be powered and configured in its launch configuration. For this test the observatory will be attached to the test PAF.

The environmental test director representing the project for the this test will most likely be the Structural Subsystem Lead Engineer.

10.2.7 MECHANICAL SHOCK

A mechanical shock test will be performed on the TRMM Observatory. This test will simulate the separation of the observatory from the launch vehicle thus subjecting the observatory to the mechanical shock impulse generated. This test will be performed by firing the separation pyrotechnics between the observatory and the test PAF. It is envisioned that either the test PAF will be dropped clear of the observatory or the observatory will be lifted free of the test PAF to demonstrated actual separation. In addition, the pyrotechnics for the deployables (solar arrays, HGA, and the TMI bucket and antenna) will be fired thus also subjecting the observatory to the mechanical shock pulses generated. During the mechanical shock test the observatory will be powered and configured in its launch configuration. For this test the observatory will be attached to the test PAF.

The environmental test director representing the project for the this test will most likely be either the Structural Subsystem Lead Engineer or the Spacecraft Systems Engineer.

10.3 ENVIRONMENTAL TEST PROGRAM SCHEDULE

The TRMM Project Schedule Baseline Document, document TRMM-490-165, shows the currently planned schedule for the TRMM environmental test program along with all other major observatory level I&T events. (See Figure 8-1, TRMM Observatory I&T Schedule, for the current schedule of the TRMM environmental test program).

11.0 SHIPMENT AND LAUNCH SITE ACTIVITIES

The purpose of this section is to give an overview of the requirements and process of shipping the TRMM Project to the launch site and the activities planned once the TRMM Project arrives at the launch site. The usage of the term "TRMM Project" here refers to the TRMM Observatory, all required GSE, all necessary documentation, and all personnel required to support the launch site activities. The launch site for the TRMM Observatory is the Tanegashima Space Center (TnSC), located at the south end of Tanegashima Island. Tanegashima Island is located at the north end of the Ryukyu Islands which are located in the southern part of Japan.

11.1 SHIPMENT

The usage of the term "shipment" in this section refers to packing, crating, boxing, loading, and transport of the TRMM Observatory, including all un-integrated flight hardware, all required GSE, and all necessary documentation required (or that might be required) at the launch site. The purpose of this section is to give an overview of the "shipment" process and how and what will be shipped.

Project support personnel in conjunction with GSFC Code 234 personnel will plan, coordinate, and handle all of the logistics for the shipment of the TRMM Project from the GSFC to the launch site. Also, they will be responsible for the implementation and execution of these plans.

The intention of this section is to only give a brief overview of the shipment of the TRMM Project. More details can be found in the TRMM Observatory Shipping Implementation Plan (TBD), document TRMM-TBD-TBD.

11.1.1 OBSERVATORY SHIPMENT

Once the TRMM Observatory has successfully completed all I&T activities at the GSFC, it will be prepared for shipment to the launch site. The observatory, located in the SSDIF will be loaded into the TRMM shipping container. (See section 7.4.2.3). After the observatory has been loaded and prepared for shipment, the shipping container will be loaded onto the transporter where the observatory will be transported to a local TBD air/sea terminal for transcontinental transport.

11.1.2 GSE SHIPMENT

Once the TRMM Observatory has successfully completed all I&T activities at the GSFC, all GSE (including the EGSE, the SGSE, the IGSEs, required MGSE, required BGSE, and all other miscellanous GSE) shall be moved to the GSFC building 29 trucklock area where it will be packed, crated, and boxed in preparation for shipment. Then the GSE will be loaded onto a truck where it will be transported to the same local air/sea terminal as the observatory where it will accompany the observatory for transcontinental transport.

11.1.3 PROJECT SUPPORT PERSONNEL

A number of personnel supporting the TRMM Project will be required, at various times and for various durations, at the launch site to support various launch site activities.

The actual list of personnel required at the launch site, and the duration that their services might be required will be determined by the TRMM Project Office prior to shipment. However, the following areas of support are expected to be required:

- Project Management
- Project Support Personnel (including secretaries)
- FAM and QA personnel (including safety manager)
- Launch Site Interface Manager
- I&T Manager (including I&T Support Managers, and I&T coordinator)
- Spacecraft Test Conductors
- Instrument Managers
- Instrument Test Conductors
- Spacecraft Subsystem Personnel
- Electrical Technicans
- Mechanical Technicans
- EGSE Personnel (software and hardware)
- SGSE Personnel (software and hardware)
- Battery Personnel
- Contamination Control Personnel
- Code 500 Personnel
- Other TBD Personnel

In addition, as unforseen reasons could present themselves at the launch site, additional personnel may be required at the launch site.

11.2 LAUNCH SITE ACTIVITIES

The intention of this section is to only give a brief overview of the launch site activities for the TRMM Project. In addition, this section will give a brief overview of the various facilities the TRMM Project will use at the launch site and the requirements imposed on these facilities by the TRMM Project. More details about these subjects can be found in the TRMM Implementation Plan (Volume No. 2 - Launch Operations), document TRMM-490-009; the TRMM Launch Site Support Plan (TBD), document TRMM-TBD-TBD; and the TRMM Spacecraft - Launch Operations Interface Control Specification (TBD), document TRMM-TBD-TBD. (For a preliminary schedule of the launch site I&T activities, see Figure 11-1, TRMM Launch Site Activities).

11.2.1 LAUNCH SITE FACILITIES AND REQUIREMENTS

The TRMM Project will require the use of various facilities at the launch site. These include the following:

* #2STA
  - Unpacking Room
  - GSE Storage Room
  - Checkout Room
  - Spacecraft Preparation Hall
  - Other TBD areas

* Spacecraft and Fairing Assembly building (SFA)
  - Fueling and Assembly Hall
  - Spacecraft / Fairing Assembly Hall
  - Other TBD areas

* Payload Service Tower (PST)
  - GSE area at upper spacecraft access level

* Blockhouse
  - GSE area

* SFA Storage Shed

* Pyrotechnic Storage Facility

See Figure 11-1 for the location of these launch site (TnSC) facilities.

11.2.1.1 #2STA

The #2 Spacecraft Testing and Assembly hall (#2STA) (see Figure 11-2) will be the "home base" for operating and testing the TRMM Observatory while at the launch site. It will also be the area where a major portion of the actual launch site testing and final preparations on the observatory will take place.

11.2.1.1.1 FACILITY REQUIREMENTS

Facility requirements imposed on the #2STA by the TRMM Project include the following categories:

- GSE Space and Power Requirements
- Communications
- Contamination Control
- Pressurized Air
- Other Facility Requirements

11.2.1.1.1.1 GSE SPACE AND POWER REQUIREMENTS

Various power services will be required in the #2STA to operate the EGSE, the BGSE, the MGSE, the SGSE, the IGSEs, and various other GSE. Not only will these services be required in the #2STA but they will need to be available in the appropriate areas. In addition, a reasonable amount of space will be required for the operation and for access to this GSE. (See Appendix B for the power requirements and size of the GSE).

11.2.1.1.1.2 COMMUNICATIONS

Various communication links will be required in the #2STA. At a minimum this includes voice links to the MOC located at the GSFC, to the blockhouse, to the PST, possibly to the SFA, and possibly within the #2STA itself. A CCTV link to the PST will be required and possibly a CCTV link within the #2STA itself. Also, command and telemetry data interfaces to the PST, to the MOC, and possibly to the SFA will be required. In addition, a RF interface to the portable TDRSS antenna will be required.

11.2.1.1.1.3 CONTAMINATION CONTROL

Contamination controlled areas will be required in the #2STA by the TRMM Project. While the cleanrooms in the #2STA are nominally class 100,000; every reasonable attempt will be made to better this level by following the procedures in the Launch Site Contamination Control Plan, document TRMM-724-TBD.

A large contamination controlled area will be required to contain the TRMM Observatory for the duration it is located in the #2STA. This area must be large enough (approximately 50 feet x 50 feet) to contain the observatory and all required MGSE for the solar array deployment test. (This test configuration requires the maximum space). Also, a contamination controlled area will be required to perform the inspection and any stand-alone checkout and testing of the solar arrays.

A nitrogen gas (MIL P27401C) purge will be required at times by both the VIRS CERES, and TMI Instruments while the TRMM Observatory is located within the #2STA (see paragraph 3.3.3).

The TRMM contamination control team will require an area in the #2STA for cleaning hardware and tools prior to entry into the cleanroom. (This area may actually be located just inside the cleanroom).

11.2.1.1.1.4 PRESSURIZED AIR

A clean pressurized (approximately 100 psi) air source is required in the #2STA. This air source is required by the G-negation MGSE used to support deployment testing of the solar array wings and at times by the TRMM Rotating Dolly.

11.2.1.1.1.5 OTHER FACILITY REQUIREMENTS

Other facility requirements include:

- storage area for GSE and shipping materials
- office space for TRMM Project personnel
- conference room with a speaker telephone
- telephones and a FAX machine
- facility temperature and humidity control
- grounding for spacecraft structure ("quiet" grounding plate)
- gaseous nitrogen supply (MIL P27401C)
- raised flooring in checkout room
- mounting site for portable TDRSS antenna
- TBD others

11.2.1.2 SFA

After the completion of all testing and preparation activities in the #2STA, the TRMM Observatory will be moved to the Spacecraft Fairing and Assembly building (SFA) (see Figure 11-3). This move will be accomplished by loading the observatory into the a NASDA provided transporter (using NASDA's test PAF and transporter base) and moving it to the SFA. Once inside the SFA the observatory will be removed from the NASDA transporter. (The test PAF and transporter base are to be immediately returned to NASDA). The SFA contains two major areas where TRMM activities will take place. These two areas are: (1) the Fueling and Assembly Hall, and (2) the Spacecraft / Fairing Assembly Hall. The observatory will first be set up in the Fueling and Assembly hall.

11.2.1.2.1 SFA FUELING AND ASSEMBLY HALL

The SFA Fueling and Assembly Hall is the area where the RCS will be fueled.

At this time there is no requirement for the observatory to be powered while in the SFA Fueling and Assembly Hall. If this requirement changes, the required EGSE will be required in the SFA and the SGSE will either be required in the SFA or the proper interfaces between the observatory located in the SFA and the SGSE located in the #2STA will be required. However, at times, if possible TBD monitoring of the RCS and the batteries may be required using their respective GSE.

11.2.1.2.1.1 FACILITY REQUIREMENTS

Facility requirements imposed on the SFA Fueling and Assembly Hall by the TRMM Project include the following categories:

- GSE Space and Power Requirements (for RCS and Battery GSE)
- Contamination Control
- Other Facility Requirements

11.2.1.2.1.1.1 GSE SPACE AND POWER REQUIREMENTS

Various power services will be required in the SFA Fueling and Assembly Hall to operate the RCS GSE required for the RCS fueling operation. In addition, BGSE will be required in the SFA to monitor the batteries and to perform any final battery reconditioning. A reasonable amount of space will be required for the operation and for access to this GSE. (See Appendix B for the power requirements and size of the RCS GSE and BGSE).

11.2.1.2.1.1.2 CONTAMINATION CONTROL

A large contamination controlled area will be required to contain the TRMM Observatory for the duration it is located in the SFA Fueling and Assembly Hall. This area must be large enough to contain the observatory and all GSE required for the RCS fueling operations. While the cleanroom in the SFA Fueling and Assembly Hall nominally is class 100,000; every reasonable attempt will be made to better this level by following the procedures in the Launch Site Contamination Control Plan, document TRMM-724-TBD.

A nitrogen gas (MIL P27401C) purge will be required at times by both the VIRS CERES, and TMI Instruments while the TRMM Observatory is located within the SFA Fueling and Assembly Hall (see paragraph 3.3.3).

The TRMM contamination control team will require an area in the SFA for cleaning hardware and tools prior to entry into the SFA Fueling and Assembly Hall cleanroom. (This area may actually be located just inside the cleanroom).

11.2.1.2.1.1.3 OTHER FACILITY REQUIREMENTS

Other facility requirements include:

- storage area for GSE
- safety equipment
- limited office/work space for TRMM Project personnel
- telephones
- facility temperature and humidity control
- grounding for spacecraft structure ("quiet" grounding plate)
- gaseous nitrogen supply (MIL P27401C)
- TBD others

11.2.1.2.2 SFA SPACECRAFT / FAIRING ASSEMBLY HALL

Once the RCS fueling operation has been completed, the TRMM Observatory will be moved to the SFA Spacecraft / Fairing Assembly Hall. In this area the observatory will be attached to the flight PAF and then encapsulated by the upper fairing assembly.

(At this time there is no requirement for the observatory be powered at all while in this facility. However, at times, if possible TBD monitoring of the RCS and the batteries may be required using their respective GSE).

11.2.1.2.2.1 FACILITY REQUIREMENTS

Facility requirements imposed on the SFA Spacecraft / Fairing Assembly Hall by the TRMM Project include the following categories:

- GSE Space and Power Requirements
- Contamination Control
- Other Facility Requirements

11.2.1.2.2.1.1 GSE SPACE AND POWER REQUIREMENT

(At this time there is no requirement for the observatory be powered at all while in this facility. However, at times, if possible the requirement may be imposed for TBD monitoring of the RCS and the batteries. If this requirement is imposed, adequate space and power services for the required GSE will be needed.)

1.2.1.2.2.1.2 CONTAMINATION CONTROL

The TRMM Observatory should be maintained in a contamination controlled environment throughout the duration that it is located in the SFA Spacecraft / Fairing Assembly Hall. While the cleanroom in the SFA Spacecraft / Fairing Assembly Hall nominally is class 100,000; every reasonable attempt will be made to better this level by following the procedures in the Launch Site Contamination Control Plan, document TRMM-724-TBD.

11.2.1.2.2.1.3 OTHER FACILITY REQUIREMENTS

Other facility requirements include:

- telephones
- facility temperature and humidity control
- TBD others

11.2.1.3 PST (LAUNCH PAD)

Once the TRMM Observatory and the companion payload have been encapsulated by the spacecraft fairing assembly, the whole spacecraft fairing assembly will be transported to the Pad Service Tower (PST) using the NASDA spacecraft fairing assembly transportion dolly.

Once the spacecraft fairing assembly arrives at the PST, it will be lifted to the top of the PST where it will be mated to the top of the H-II launch vehicle. At this location is where the final spacecraft checkout and final closeouts are performed (see Figure 11-4).

11.2.1.3.1 FACILITY REQUIREMENTS

Facility requirements imposed on the PST (launch pad) by the TRMM Project include the following categories:

- GSE Space and Power Requirements
- Communications
- Other Facility Requirements

11.2.1.3.1.1 GSE SPACE AND POWER REQUIREMENTS

At this time, basically the only GSE required at the PST is some EGSE, BGSE, GSE used to pressurize the RCS, and some RF GSE for supporting the spacecraft end-to-end test. Adequate space and power services for this GSE will be needed at the PST.

11.2.1.3.1.2 COMMUNICATIONS

Various communication links will be required at the PST. At a minimum these includes voice links to the blockhouse and to the #2STA, including a CCTV link to the #2STA. Also, hardline command and telemetry data interfaces (along with other umbilical interface like spacecraft power, control, and monitoring interfaces) to the EGSE located in the blockhouse are required. In addition, RF command and telemetry interfaces between the PST and the portable TDRSS antenna located at the PST will be required to support the PST end-to-end test.

11.2.1.3.1.3 OTHER FACILITY REQUIREMENTS

Other facility requirements include:

- any required safety equipment
- facility temperature and humidity control (fairing air conditioning)
- gaseous nitrogen supply
- mounting site for portable TDRSS antenna
- emergency off-loading drain for RCS propellant
- TBD others

11.2.1.4 BLOCKHOUSE

During the period of time when the spacecraft is being encapsulated and is being transported to the PST, all required GSE will be re-located to the blockhouse (see Figure 11-5). This GSE is comprised basically of the EGSE. Also during this time, this GSE will be set up and checked out. The purpose of having this GSE in the blockhouse is that it is the closest location to the PST where it can be safely located. This GSE will provide external power, command and telemetry, and other interfaces to the TRMM Observatory while it is at the PST.

11.2.1.4.1 FACILITY REQUIREMENTS

Facility requirements imposed on the Blockhouse by the TRMM Project include the following categories:

- GSE Space and Power Requirements
- Communications
- Other Facility Requirements

11.2.1.4.1.1 GSE SPACE AND POWER REQUIREMENTS

t this time, basically the only GSE required at the Blockhouse is the EGSE. Adequate space and power services for the EGSE will be needed at the Blockhouse.

11.2.1.4.1.2 COMMUNICATIONS

Various communication links will be required in the Blockhouse. At a minimum these include voice links to the PST and to the #2STA. Also, hardline command and telemetry data interfaces (along with other umbilical interface like spacecraft power, control, and monitoring interfaces) to the spacecraft located at the PST are required.

11.2.1.4.1.3 OTHER FACILITY REQUIREMENTS

Other facility requirements include:

- telephones
- TBD others

11.2.2 LAUNCH SITE ARRIVAL

When the TRMM Observatory and all its GSE arrives at the launch site it will be delivered to the appropriate areas of the #2STA. All test and flight pyrotechnics will be delivered to the pyrotechnics storage facility where they will be inspected and safely stored until required. The RCS propellent, which will be contained in a Generic Propellant Transfer Unit (GPTU), will be delivered to the SFA Fueling and Assembly Hall where a sample will be taken for test (to determine its purity) and then moved into the SFA Storage Shed where it will be safely stored until it is required in the SFA Fueling and Assembly Hall for fueling the RCS.

11.2.2.1 RECEIVING AND INSPECTION

Upon the arrival of the TRMM Project at the various launch facilities, receiving and inspection activities will be performed on all flight hardware, GSE, and other supporting elements.

11.2.2.1.1 OBSERVATORY

Upon the arrival of the TRMM Observatory and the appropriate support personnel, the TRMM Observatory will be unloaded from the TRMM shipping container. Once unloaded, the TRMM Observatory will be inspected for visible signs of damage and contamination (including moisture). Also, the TRMM shipping container will be inspected for damage, contamination, moisture, and other visible problems.

The flight solar arrays and the flight batteries will be shipped to the launch site in separate containers. Upon their arrival and the arrival of the appropriate support personnel, they will be unloaded from their respective shipping containers. Once unloaded, they will also be inspected for visible signs of damage and contamination (including moisture). Also, both the solar array and the battery shipping containers will be inspected for damage, contamination, moisture, and other visible problem.

11.2.2.1.2 GSE

Upon the arrival of the various types of GSE and the appropriate support personnel, the GSE will be uncrated and/or unpacked. The GSE will be inspected for visible signs of damage or other problems.

11.2.3 #2STA OPERATIONS AND TESTING

Once the observatory and the GSE has been unpacked and inspected, various operations and testing will be performed in the #2STA for preparing the TRMM Observatory for the upcoming launch. These operations and test include the following:

- Observatory Setup
- GSE Setup
- Mechanical Alignment and Adjustments (as needed)
- Initial Spacecraft Power Up Test
- Observatory Performance Test
- Spacecraft End-To-End Test
- Integrate and Test Flight Batteries
- Install RCS Flight Enable Plug
- Integrate Solar Arrays / Perform Deployment Test for Solar Arrays, HGAD/PS, and TMI/ Install Flight Pyrotechnics for Solar Arrays, HGAD/PS, TMI, and RCS Pyrotechnic Valve
- MLI blanket Closeout
- Pack Up And Move Observatory And Required GSE To SFA
- Other TBD Operations And Test As Required

11.2.3.1 OBSERVATORY SETUP

The TRMM Observatory will be set up in the #2STA Spacecraft Preparation Hall which is a contamination controlled area. The observatory will be configured in the TRMM Vertical Dolly. A complete contamination inspection and cleaning of the observatory will be performed as required.

The flight solar arrays will be set up for inspection and for any required stand-alone testing away from the observatory in the #2STA Spacecraft Preparation Hall. A complete contamination inspection and cleaning of the flight solar arrays will be performed as required. If no testing is required, or once the testing is complete, the solar arrays will be stored in this contamination controlled area, in a safe area and manner, and away from all operations until they are integrated onto the observatory.

Upon arrival the flight batteries will be set up for charging; and for any required stand-alone testing, monitoring, and conditioning activities. A complete contamination inspection and cleaning of the flight batteries will be performed as required. If no testing is required, or once the testing is complete, the flight batteries shall be safely placed on the battery cooling cart and placed on trickle charge until they are integrated onto the observatory. Also upon arrival, the test batteries will be charged; and cleaned and integrated onto the observatory if shipped separately.

11.2.3.2 GSE SETUP

The EGSE, the SGSE, and the IGSEs will be set up and configured in the #2STA Checkout Room much like they were at the GSFC. Before any connections are made to the spacecraft, this GSE will be tested and verified that it is operating correctly.

BGSE will be set up as required to support any required battery testing, monitoring, or conditioning operations.

Other GSE will be set up as required.

11.2.3.3 ALIGNMENT VERIFICATION AND ADJUSTMENTS

Once the observatory setup is complete, the alignment of the instrument sensors, and various subsystem components requiring alignment will be verified. If any component if found out of alignment it will be adjusted and verified.

11.2.3.4 INITIAL SPACECRAFT POWER UP TEST

Once the observatory setup is complete, the alignments have been verified and any required adjustments made, and the EGSE, the SGSE, and the IGSEs have been set up and tested, the umbilicals will be mated to the Observatory. An initial spacecraft power up test will be performed to verify that all GSE and interfaces between the observatory and the GSE are working properly.

11.2.3.5 OBSERVATORY PERFORMANCE TEST

An full Observatory Performance Test (long form functional test) will be performed. The purpose of this test is to verify that the spacecraft and its instruments are working properly and that nothing has changed since the observatory was shipped from the GSFC. In general, this test will be the same as the observatory level long form functional test performed at the GSFC.

11.2.3.6 SPACECRAFT END-TO-END TEST

A Spacecraft End-To-End Test will be performed while the spacecraft is located in the #2STA. An antenna (provided by GSFC Code 500) will be located on the roof of the #2STA. This antenna will provide two-way communications between the TRMM Observatory and the TDRSS. The purpose of this test is to re-verify the readiness of all ground systems. Also, this test will perform a second validation of the spacecraft RF communications subsystem.

11.2.3.7 INTEGRATE AND TEST FLIGHT BATTERIES

The spacecraft test batteries will be de-integrated and the flight batteries will be mechanically and electrically integrated and tested. These activities will be performed in the #2STA and must be completed prior to the installation of the solar array wing mounted on the +Y axis side of the observatory.

11.2.3.8 INTEGRATE SOLAR ARRAYS / PERFORM DEPLOYMENT TEST / INSTALL FLIGHT PYROTECHNICS

A full deployment test of each solar array wing, the HGA, and the TMI bucket and antenna is planned for while the observatory is in the #2STA. One deployment will be performed at a time. Each deployment test includes the following applicable steps (the actual order is TBD):

- configure observatory for integration
- perform pyrotechnic stray voltage check
- mechanically install test pyrotechnics
- electrically integrated test pyrotechnics
- mechanically and electrically integrate and test solar array
- check or perform alignment of deployable
- configure observatory and deployment GSE for test
- power spacecraft and perform deployment test
- power down spacecraft

Once the deployment test is complete,the applicable deployable will be configured for flight. This includes the following applicable steps (the actual order is TBD):

- remove test pyrotechnic
- check or perform alignment of deployable
- perform pyrotechnic stray voltage check
- mechanically install flight pyrotechnics
- electrically integrated flight pyrotechnics
- stow deployable

The actual order of testing the deployables is TBD. However, before the solar arrays are stowed for flight, any access to the internal portion of the spacecraft behind the solar arrays must be performed. Therefore, the flight pyrotechnics for the RCS pyrotechnic valve will be installed before this point.

11.2.3.9 MLI BLANKET CLOSEOUT

Upon completion of all operations on the observatory while it is located in the #2STA and before the observatory is re-located to the SFA, the MLI blankets will be closed out to the fullest extent possible. A few areas will be required to be left open since a limited amount of access to the observatory will still be required.

11.2.3.10 COMETS END-TO-END TEST

An end-to-end test will be performed with the COMmunications Engineering Test Satellite (COMETS) system while the TRMM Observatory is in the #2STA. This test will be similar to the spacecraft end-to-end test also performed in the #2STA with the TDRSS. During the COMETS end-to-end test, the COMETS ground station will establish the forward link so that the it can process a coherent telemetry link but it will not command the TRMM Observatory. (Note that if meeting the scheduled launch date is a concern this test may be deleted).

11.2.3.11 PACK UP AND MOVE OBSERVATORY AND REQUIRED GSE TO SFA

Upon completion of all I&T activities in the #2STA, the TRMM Observatory will be packed up and moved to the SFA Fueling and Assembly Hall. The observatory will be loaded into the NASDA provided transporter for its transport to the SFA. All GSE required in the SFA will also be located to the SFA. (GSE not previously required in the #2STA should already be located in the SFA, checkout, and ready for use).

11.2.3.12 PACK UP AND MOVE REQUIRED GSE TO BLOCKHOUSE/PST

At this time there is no requirement to power and operate the observatory while it is located in the SFA. If this requirement remains true, once the observatory is re-located to the SFA, all GSE required in the blockhouse/PST (basically the EGSE) can be packed up and moved from the #2STA to the blockhouse/PST. The sooner this GSE is re-located to the blockhouse/PST, the more time that will be available to get it installed and checked out. In addition, this will allow more time to be available to verify interfaces between the blockhouse and the PST and between the blockhouse and the #2STA.

11.2.4 SFA OPERATIONS

There are two primary operations to be performed in the SFA. First, the RCS is to be fueled. This will be performed in the SFA Fueling and Assembly Hall. Second, the observatory is to be mated to the flight PAF and encapsulated by the fairing. This will be performed in the SFA Spacecraft / Fairing Assembly Hall.

11.2.4.1 UNPACK AND INSPECT OBSERVATORY / GSE

Once the observatory arrives in the SFA it will be unloaded from the transporter. The test PAF is to be immediately removed from the observatory and returned to NASDA along with the transporter base. Next the observatory will be inspected for damage and contamination. Also, any GSE re-located to the SFA will be loaded, unpacked, and inspected for damage.

At a minimum, the RCS and battery GSE will be required in the SFA for RCS fueling activities and battery charging and monitoring activities.

11.2.4.2 SET UP OBSERVATORY / GSE FOR RCS PROPELLANT LOADING

Once the observatory and required GSE is located to the SFA Fueling and Assembly Hall it will be set up for RCS propellant loading.

11.2.4.3 INSTALL RCS FLIGHT ENABLE PLUG

The RCS flight enable plug must be installed prior to the RCS fueling operation. (The RCS functional testing previously performed in the #2STA as part of the observatory performance test required the use of a test enable plug).

11.2.4.4 RCS PROPELLANT LOADING

Just prior to propellant loading, a fuel sample will be taken from the loading system and tested. Upon completion, the RCS will be fueled. RCS GSE will be used to perform this operation and to monitor the RCS. The spacecraft will not be powered during this operation or during any operation in the SFA.

11.2.4.5 PRESSURIZE RCS

he RCS will be pressurized while in the SFA Fueling and Assembly Hall. The pressurant used is gaseous nitrogen. RCS GSE will be used to perform this operation and to monitor the RCS. The spacecraft will not be powered during this operation or during any operation in the SFA.

11.2.4.6 BATTERY RECONDITIONING AND INITIAL RED/GREEN TAG WALKDOWN

Upon completion of the RCS fueling, any battery reconditioning will be performed. Since the flight batteries are on the observatory and not directly accessible at this time, and battery recondition will have to be performed at the external battery test panel. This will only allow a "short form" reconditioning to be performed.

At this time, an initial red/green tag walkdown and any remaining closeouts should be performed since this will be the last opportunity for general access to the observatory. Once the observatory has been encapsulated any and all access to the observatory will have to be through the fairing access ports.

11.2.4.7 OBSERVATORY FINAL WEIGHT & BALANCE CHECK

Upon completion of the RCS fueling, the observatory will be weighed and a final balance check will be performed.

11.2.4.8 MOVE OBSERVATORY TO SFA SPACECRAFT / FAIRING ASSEMBLY HALL

After completion of the planned activities in the SFA Fueling and Assembly Hall, the TRMM Observatory will be moved into the SFA Spacecraft / Fairing Assembly Hall using the TRMM Vertical Dolly.

11.2.4.9 PAF MATING AND FAIRING ENCAPSULATION

The operations to be performed while the TRMM Observatory is located in the SFA Spacecraft / Fairing Assembly Hall are: the mating the observatory to the flight PAF, and the encapsulation of the observatory by the fairing assembly.

11.2.4.10 MOVE OBSERVATORY TO PST

After the fairing assembly is completed (which contains the TRMM Observatory and the companion payload), the whole spacecraft fairing assembly will be transported to the Payload Service Tower (PST) using the NASDA spacecraft fairing assembly transportion dolly. Prior to the actual transport, the entire fairing assembly will be pressurized to a small positive pressure to help minimize the risk of any contaminants getting into the fairing assembly and onto the payloads.

11.2.5 PST (LAUNCH PAD) OPERATIONS AND TESTING

Operations and testing to be performed at the PST (launch pad) for the TRMM Observatory include the following:

- Set Up And Checkout PST EGSE And Umbilical Interface
- Observatory Mate To Launch Vehicle
- Mate Battery Cooling GSE And Umbilical To Spacecraft
- Observatory Aliveness Test
- Spacecraft End-To-End Test
- Launch Dress Rehearsal
- Red/Green Tag Walk Down, Final Closeouts, & Arming Plug Installation
- Removal Of Battery Cooling GSE
- Launch

11.2.5.1 SET UP AND CHECKOUT PST EGSE AND UMBILICAL INTERFACE

Once the TRMM Observatory is delivered to the SFA, all EGSE required at the PST will be relocated to the PST, set up and checked out. Once completed, the PST EGSE will be checked out with the EGSE located in the blockhouse. Also, the umbilical interface between the EGSE located at the blockhouse, the EGSE located at the PST, and the umbilical interface to the H-II fairing for the TRMM Observatory will be checked out and verified.

11.2.5.2 OBSERVATORY MATE TO LAUNCH VEHICLE

Upon the arrive of the fairing assembly (which contains the TRMM Observatory and the accompanying payload) at the PST, a crane at the PST will be used to hoist the fairing assembly to the 12th floor level of the PST. At this point the fairing assembly will be mated to the H-II launch vehicle.

11.2.5.3 MATE BATTERY COOLING GSE AND UMBILICALS TO SPACECRAFT

Once the TRMM Observatory is mated to the H-II launch vehicle and the "all clear" is given, the battery cooling GSE and umbilicals will be mated to the TRMM Observatory.

11.2.5.4 OBSERVATORY ALIVENESS TEST

An Observatory aliveness test will be performed from the #2STA while the TRMM Observatory is at the PST. During this test all spacecraft subsystems and instruments will be tested. The purpose of this test is to demonstrate that all spacecraft subsystems and instruments are operational.

11.2.5.5 SPACECRAFT END-TO-END TEST

A final Spacecraft End-To-End Test will be performed while the spacecraft is located at the PST. An antenna (provided by GSFC Code 500) will be located at the PST (14th floor level). This antenna will provide two-way communications between the TRMM Observatory and the TDRSS. The purpose of this test is a final verification of the readiness of all ground systems. Also, this test will perform a final validation of the spacecraft RF communications subsystem.

11.2.5.6 LAUNCH DRESS REHEARSAL

After the spacecraft fairing assembly has been mated to the H-II launch vehicle and prior to launch, a dress rehearsal exercise will be performed. This dress rehearsal will be a simulation of the actual countdown. All checkouts, testing, preparations, and configuration activities required by the H-II launch vehicle, the TRMM Observatory, and the companion payload will be performed as planned according to the countdown timetable. The purpose of this exercise is to practice for the actual launch countdown, to demonstrate that the all systems are ready, and to verify the countdown timetable. (All required TRMM personnel shall be on station for this exercise).

11.2.5.7 RED/GREEN TAG WALK DOWN, FINAL CLOSEOUTS, & ARMING PLUG INSTALLATION

Just prior to the roll back of the PST, a Red/Green Tag walk down will be performed. All red tag items are to be removed while all green tag items are to be installed and configured. Also, any final closeouts will be performed. This might include any final MLI blanket closeouts. In addition, all pyrotechnic arming plugs will be installed.

11.2.5.8 REMOVAL OF BATTERY COOLING GSE

Just prior to the roll back of the PST, removal of the battery cooling GSE will be required. After this point, any battery cooling will be provided by the coolant supplied to the fairing assembly.

11.2.5.9 LAUNCH

The actual launch countdown will be performed as it was during the dress rehearsal. All checkouts, testing, preparations, and configuration activities required by the H-II launch vehicle, the TRMM Observatory, and the companion payload will be performed as planned according to the countdown timetable. All required TRMM personnel will be on station for the entire countdown sequence starting at least 1 hour prior to application of power to the TRMM Observatory. All spacecraft systems and subsystems will be monitored continuously by required I&T team personnel through umbilical disconnect at launch.

11.2.6 BLOCKHOUSE OPERATIONS

Once the TRMM Observatory is delivered to the SFA, all GSE required in the blockhouse will be relocated to the blockhouse, set up and checked out. This GSE mainly consists of the EGSE. While the spacecraft is at the PST, the EGSE located in the blockhouse will be the source of the umbilical interfaces to the spacecraft. The EGSE interface will contain all power, hardline command and telemetry, control, and monitoring interfaces to the spacecraft. The EGSE will be used in this configuration for all spacecraft power up and testing operations while the spacecraft is on the PST. (This includes launch). Just like at all other times, the EGSE will require an operator at the blockhouse to support all spacecraft power up and testing activities while the observatory is at the PST. (This also includes launch).

11.2.7 POST LAUNCH ACTIVITIES

After the launch of the TRMM Observatory, the Project may require that key personnel currently located at the launch site remain available at the launch site and not directly return home. If on-orbit telemetry is available at the launch site, this will allow these key personnel to verify the proper operation of their subsystem, and if needed to give insight on any unexpected problems that may arise. If on orbit telemetry is not available at the launch site, they should still be available, if needed, for consultation purpose with the MOC located back at the GSFC. Also, post launch activities include packing up all GSE and materials to be returned to the GSFC. Subsystem/instrument/GSE personnel shall be responsible for gathering their GSE and materials and packing them or verifying that they get packed or crated for their return back to the GSFC.

EARLY START	EARLY FINISH	ORIG DUR	1997 (MAR–AUG)
24MAR97	24MAR97	1	GSE ARRIVES IN JAPAN
24MAR97	24MAR97	1	BATTERY GSE ARRIVES IN JAPAN
24MAR97	24MAR97	1	OBS ARRIVES IN JAPAN
24MAR97	24MAR97	1	SOLAR ARRAYS ARRIVE IN JAPAN
24MAR97	24MAR97	1	GPTU ARRIVES IN JAPAN
24MAR97	24MAR97	1	PYROS ARRIVE IN JAPAN
25MAR97	25MAR97	1	GSE OFF-LOAD & UNPACK
25MAR97	25MAR97	1	BATTERY GSE OFF-LOAD/UNPACK
25MAR97	25MAR97	1	OBS OFF-LOAD/UNPACK
26MAR97	26MAR97	1	SOLAR ARRAYS OFF-LOAD/UNPACK
26MAR97	26MAR97	1	GPTU TO SFA SFA AIRLOCK #2/STORAGE SHED
26MAR97	26MAR97	1	PYROS TO PYRO STORAGE FACILITY
26MAR97	26MAR97	1	GSE INSPECTION
26MAR97	26MAR97	1	BATTERY GSE INSPECTION
26MAR97	26MAR97	1	OBS INSPECTION
26MAR97	27MAR97	2	SET-UP BATTERY GSE
27MAR97	27MAR97	1	SOLAR ARRAY INSPECTION
27MAR97	31MAR97	3	SET-UP GSE
27MAR97	27MAR97	1	RCS LEAK CHECK
27MAR97	31MAR97	3	TAKE PROPELLANT SAMPLE
27MAR97	1APR97	6	RECONDITION I&T BATTERIES
27MAR97	4APR97	7	SET-UP OBS
1APR97	1APR97	1	SOLAR ARRAY LAPPS TEST (if required)
7APR97	8APR97	2	OBS ALIGNMENT/VERIFICATION
9APR97	11APR97	3	OBS POWER TEST (w/GSFC H/L)
14APR97	16APR97	3	INSTALL RCS ENABLE FLIGHT PLUG/RCS FUNCTIONAL
14APR97	14APR97	1	SA FLASH TEST (if needed) SA CLEANING
18APR97	18APR97	1	CONTINGENCY
21APR97	1MAY97	8	PERFORMANCE/FUNCTIONAL TESTS
6MAY97	9MAY97	4	END-TO-END TEST (w/GSFC RF)
10MAY97	11MAY97	2	END-TO-END TST W/"COMETS" ON NON-INTEFER BASIS
12MAY97	13MAY97	2	SET UP FOR HGA DEPLOYMENT/FUNCTIONAL TEST
14MAY97	14MAY97	1	DELIVER HGA TEST PYROS
14MAY97	14MAY97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
14MAY97	14MAY97	1	INSTALL HGA TEST PYROS
15MAY97	16MAY97	2	PERFORM HGA DEPLOYMENT/FUNCTIONAL TEST

Plot Date 24JAN95
Data Date 18JAN95
Project Start 1JAN91
Project Finish 7NOV00

TROPICAL RAINFALL MEASURING MISSION
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Date	Revision	Checked	Approved

Figure 11-1 TRMM LAUNCH SITE ACTIVITIES

EARLY START	EARLY FINISH	ORIG DUR	ACTIVITY (1997: MAR 3 10 17 24 31 / APR 7 14 21 28 / MAY 5 12 19 26 / JUN 2 9 16 23 30 / JUL 7 14 21 28 / AUG 4 11 18 25)
19MAY97	19MAY97	1	DELIVER HGA FLIGHT PYROS
19MAY97	19MAY97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
19MAY97	19MAY97	1	INSTALL HGA FLIGHT PYROS
19MAY97	19MAY97	1	STOW HGA FOR FLIGHT
20MAY97	21MAY97	2	SET-UP TMI DEPLOYMENT/FUNCTIONAL TEST
22MAY97	22MAY97	1	DELIVER TMI TEST PYROS
22MAY97	22MAY97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
22MAY97	22MAY97	1	INSTALL TMI TEST PYROS
23MAY97	24MAY97	2	PERFORM TMI DEPLOYMENT/FUNCTIONAL TEST
26MAY97	26MAY97	1	DELIVER TMI FLIGHT PYROS
26MAY97	26MAY97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
26MAY97	26MAY97	1	INSTALL TMI FLIGHT PYROS
26MAY97	26MAY97	1	STOW TMI FOR FLIGHT
27MAY97	28MAY97	2	INTEGRATE/ALIGN SOLAR ARRAY WING (-Y)
29MAY97	29MAY97	1	PERFORM SOLAR ARRAY SUN GUN TEST
30MAY97	31MAY97	2	SET-UP FOR SOLAR ARRAY DEPLOYMENT WING (-Y)
31MAY97	31MAY97	1	FLIGHT BATTERIES ARRIVE
31MAY97	31MAY97	1	FLIGHT BATTERIES OFF-LOAD/UNPACK
31MAY97	31MAY97	1	FLIGHT BATTERY INSPECTION
1JUN97	6JUN97	6	FLIGHT BATTERY RECONDITIONING
3JUN97	3JUN97	1	DELIVER SOLAR ARRAY TEST PYROS
3JUN97	3JUN97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
3JUN97	3JUN97	1	INSTALL SOLAR ARRAY TEST PYROS WING (-Y)
4JUN97	4JUN97	1	PERFORM SOLAR ARRAY DEPLOYMENT TEST (WING -Y)
5JUN97	5JUN97	1	DELIVER SOLAR ARRAY FLIGHT PYROS (WING -Y)
5JUN97	5JUN97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
5JUN97	5JUN97	1	INSTALL FLIGHT PYROS (WING -Y)
6JUN97	6JUN97	1	STOW SOLAR ARRAY FOR FLIGHT (WING -Y)
9JUN97	10JUN97	2	REMOVE I&T BATTERY
11JUN97	12JUN97	2	INSTALL FLIGHT BATTERIES
13JUN97	14JUN97	2	INTEGRATE/ALIGN SOLAR ARRAY (WING +Y)
16JUN97	16JUN97	1	PERFORM SOLAR ARRAY SUN GUN TEST
17JUN97	18JUN97	2	SET-UP FOR SOLAR ARRAY DEPLOYMENT (WING +Y)
18JUN97	18JUN97	1	DELIVER SOLAR ARRAY TEST PYROS
18JUN97	18JUN97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
18JUN97	18JUN97	1	INSTALL SOLAR ARRAY TEST PYROS (WING +Y)

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Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

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EARLY START	EARLY FINISH	ORIG DUR	ACTIVITY (1997: MAR – AUG)
19JUN97	19JUN97	1	PERFORM SOLAR ARRAY DEPLOYMENT (+Y WING)
20JUN97	20JUN97	1	CONTINGENCY
23JUN97	23JUN97	1	DELIVER FLIGHT PYROS (WING +Y)
23JUN97	23JUN97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
23JUN97	23JUN97	1	INSTALL SOLAR ARRAY FLIGHT PYROS (WING +Y)
24JUN97	24JUN97	1	STOW SOLAR ARRAY WING FOR FLIGHT (WING +Y)
25JUN97	25JUN97	1	PERFORM PYROTECHNIC STRAY VOLTAGE TEST
25JUN97	25JUN97	1	INSTALL RCS INITIATORS
26JUN97	26JUN97	1	MLI CLOSEOUT (EXCEPT RCS FILL PORT AREA)
27JUN97	27JUN97	1	CONTINGENCY
30JUN97	30JUN97	1	PACK-UP REQUIRED GSE
30JUN97	1JUL97	2	PACK-UP OBS (OBS TO TEST PAF & TRANPORTER)
1JUL97	1JUL97	1	MOVE OBS TO SFA AIR LOCK
1JUL97	1JUL97	1	MOVE GSE TO SFA GSE STORAGE ROOM
2JUL97	2JUL97	1	UNPACK OBS (REMOVE PAF & TRANPORTER BASE)
2JUL97	2JUL97	1	MOVE OBS TO FILLING & ASSEMBLY HALL
3JUL97	3JUL97	1	UNPACK GSE & INSPECT
3JUL97	3JUL97	1	SETUP GSE
7JUL97	8JUL97	2	PREP OBS & GSE FOR PROPELLANT LOADING/FUEL SAMPL
9JUL97	10JUL97	2	START PROPELLANT LOADING
11JUL97	15JUL97	5	FLIGHT BATTERY RECONDITIONING
15JUL97	15JUL97	1	INITIAL RED/GREEN TAG WALDOWN & CLOSEOUT
15JUL97	15JUL97	1	MLI CLOSEOUT
16JUL97	16JUL97	1	PERFORM FINAL WEIGHT & BALANCE CHECK
16JUL97	16JUL97	1	MOVE BLOCKHOUSE GSE TO BLOCKHOUSE
16JUL97	16JUL97	1	CHECK FLIGHT PAF AVAILABILITY
17JUL97	17JUL97	1	PRESSURIZE RCS SYSTEM
17JUL97	17JUL97	1	SET-UP BLOCKHOUSE GSE
17JUL97	17JUL97	1	MOVE OBS TO SFA FAIRING & ASSEMBLY HALL
17JUL97	17JUL97	1	MATE FLIGHT PAF TO OBS
18JUL97	18JUL97	1	LOWER FAIRING ENCAPSULATION
18JUL97	18JUL97	1	PERFORM UMBILICAL CABLE TO B/H GSE CHECKOUT
18JUL97	18JUL97	1	PERFORM B/H TO #STA GSE CHECKOUT
19JUL97	19JUL97	1	UPPER FAIRING ENCAPSULATION
19JUL97	19JUL97	1	FAIRING ASSEMBLY/PAYLOAD ON TRANSPORTER
20JUL97	20JUL97	1	TRANSPORT PAYLOAD TO PST

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Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

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EARLY START	EARLY FINISH	ORIG DUR	ACTIVITY (1997)
20JUL97	20JUL97	1	BATTERY AC INSTALLED
20JUL97	20JUL97	1	OBS UMBILICAL CONNECTED
20JUL97	20JUL97	1	BEGIN BATTERY TRICKLE CHARGE
20JUL97	21JUL97	2	PAYLOAD TO H-II LAUNCH VEHICLE MATE
22JUL97	22JUL97	1	PERFORM OBS ALIVENESS TEST
24JUL97	24JUL97	1	PERFORM OBS END-TO-END TEST (RF)
29JUL97	29JUL97	1	BEGIN COUNTDOWN
29JUL97	29JUL97	1	LAUNCH DRESS REHEARSAL
29JUL97	29JUL97	1	FINAL RED/GREEN TAG WALKDOWN & CLOSEOUT
30JUL97	30JUL97	1	NO SPACECRAFT ACTIVITY
31JUL97	31JUL97	1	INSTALL ARMING PLUGS
31JUL97	31JUL97	1	BATTERY AC GSE REMOVED (LAST S/C ACCESS TIME)
31JUL97	31JUL97	1	PST ROLLBACK
31JUL97	31JUL97	1	FINAL OBS LAUNCH CONFIGURATION
31JUL97	31JUL97	1	FAIRING COOLANT SWITCH
31JUL97	31JUL97	1	BEGIN TERMINAL COUNTDOWN
1AUG97	1AUG97	1	TEMINATE OBS UMB PWR/LAUNCH !
2AUG97	4AUG97	3	PACK UP GSE
5AUG97	5AUG97	1	SHIP GSE BACK TO GSFC

1997: MAR 3 10 17 24 31 | APR 7 14 21 28 | MAY 5 12 19 26 | JUN 2 9 16 23 30 | JUL 7 14 21 28 | AUG 4 11 18 25

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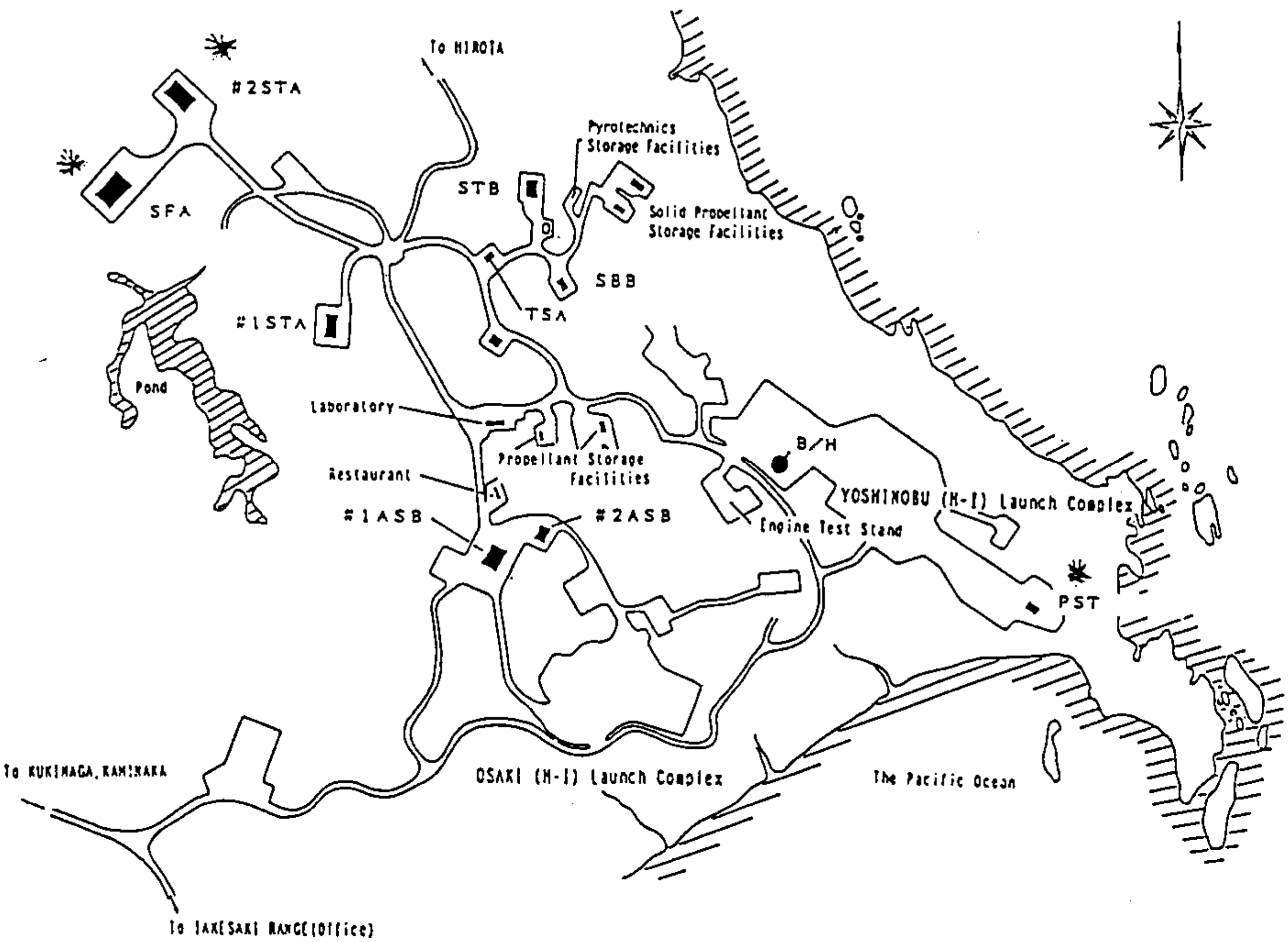

Figure 11-2 LOCATION OF TnSC FACILITIES

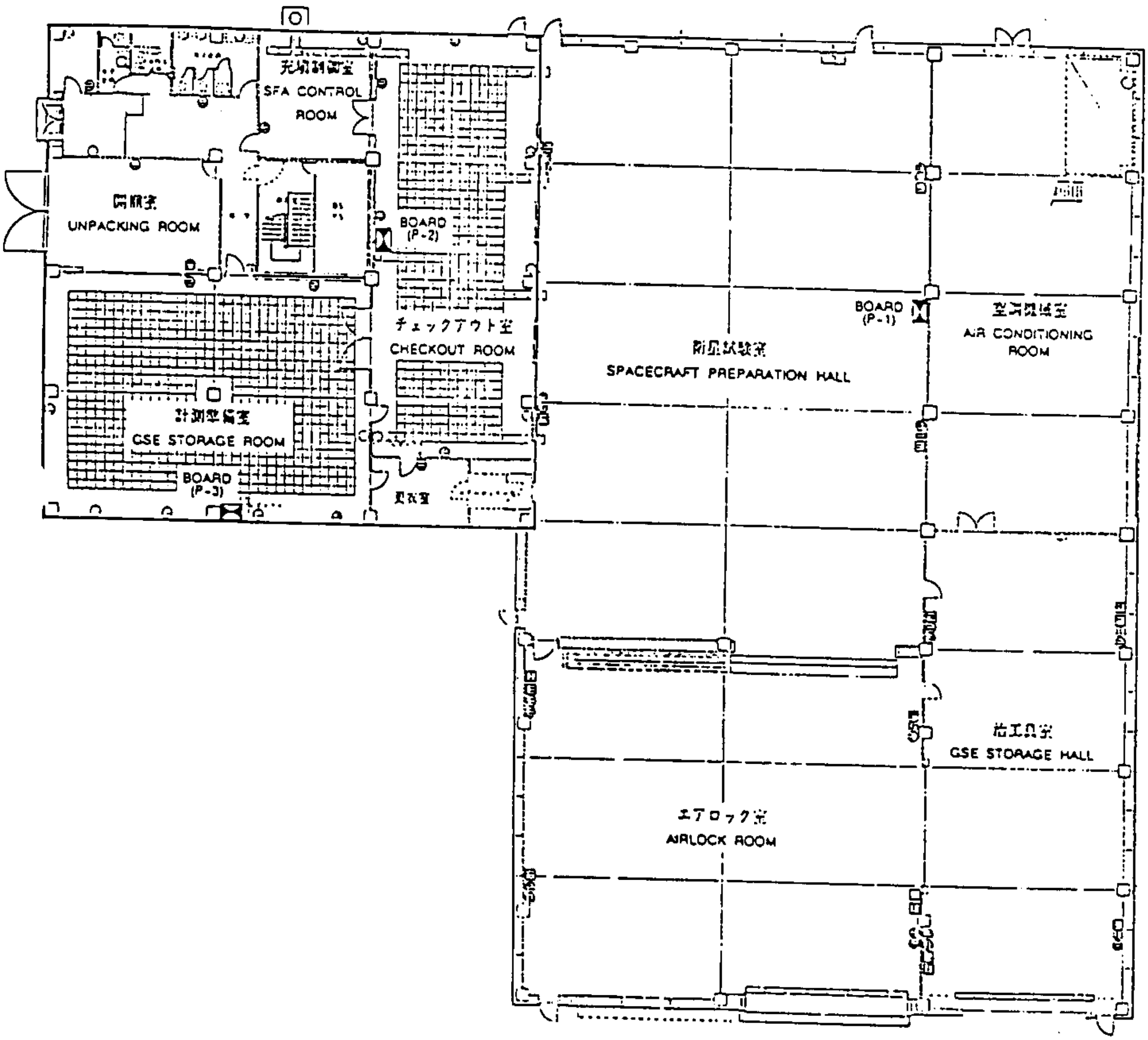

Figure 11-3 #2STA

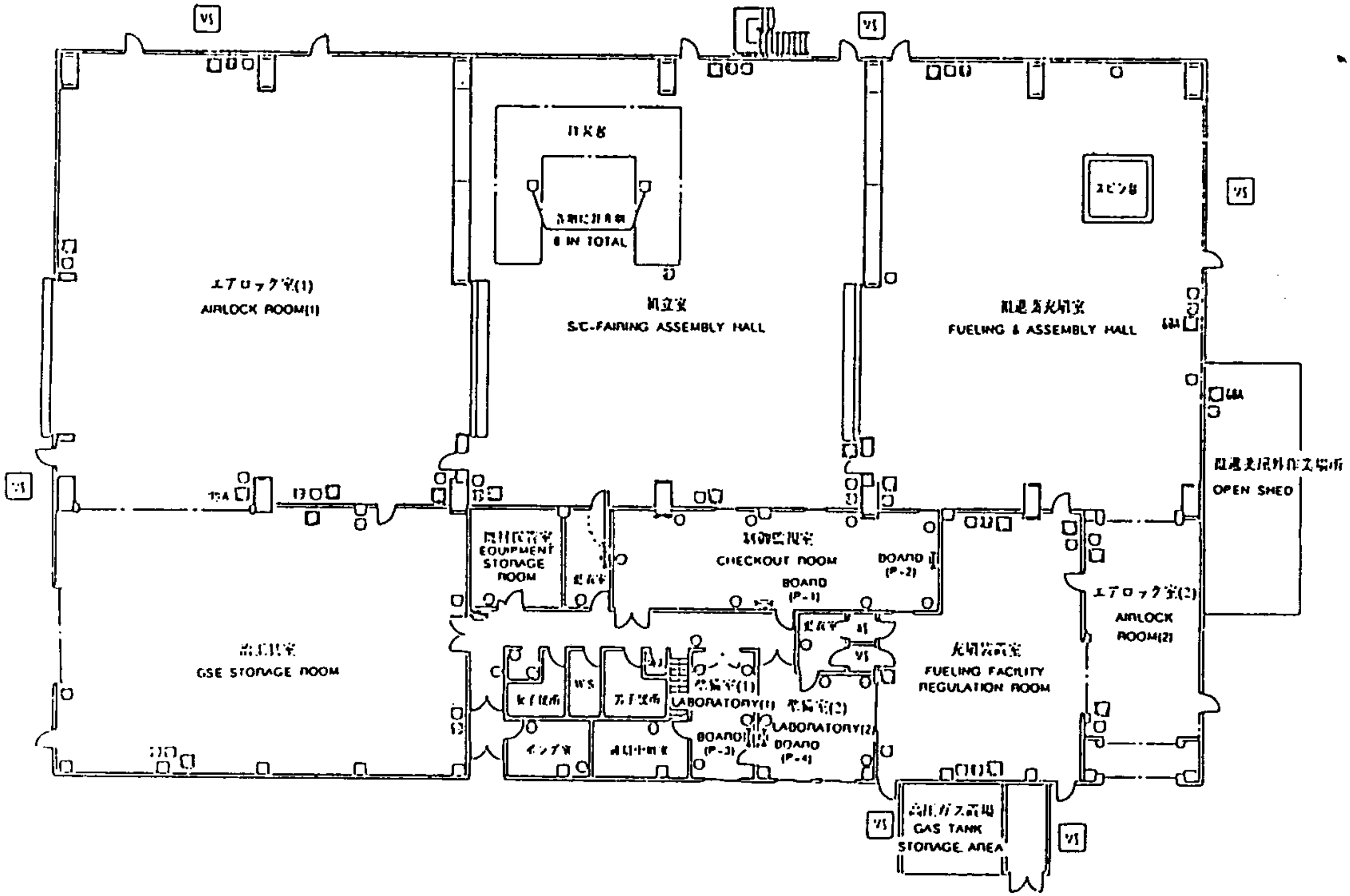

Figure 11-4 SFA

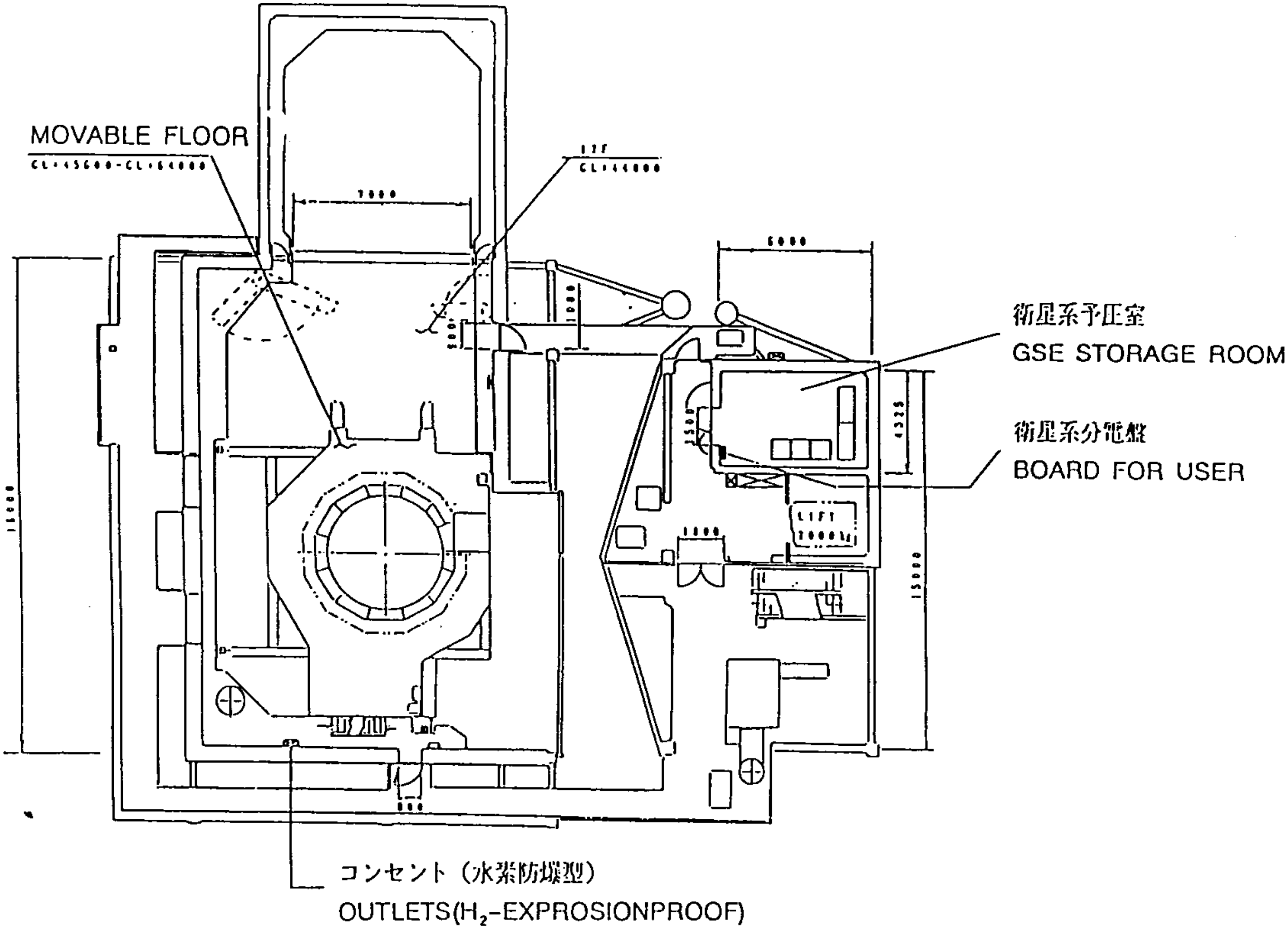

Figure 11-5 PST

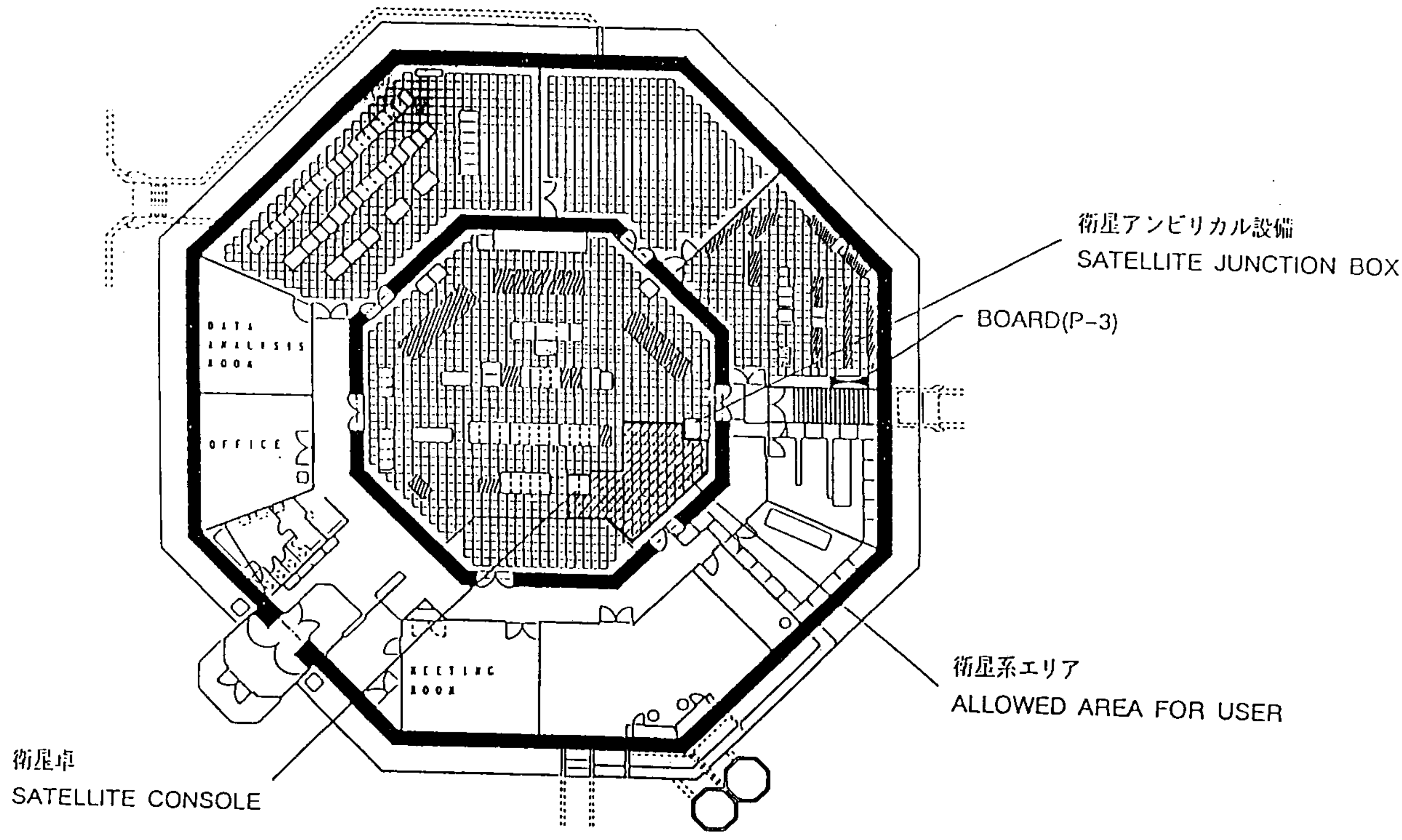

Figure 11-6 BLOCKHOUSE

12.0 CONTINGENCY PLANS AND OPERATIONS

The purpose of this section is to describe the contingency plans and operations for the TRMM I&T effort at the GSFC and at the launch site (TnSC). These plans and operations will only be described in a general and brief form since it is impossible to plan and prepared for an infinite number of unknown situations which could occurr at any point throughout the I&T schedule. However, the main thrust of contingency plans and operations are to plan for work-arounds when an unplanned or unforeseeable problem presents itself, thus allowing work to continue, progress to be make, and most importantly allowing schedule to be maintained.

It should be noted that when contingency plans and operations are implemented they must be such that no compromise is made to the safety of any personnel or flight hardware. All work-arounds must be approved by the appropriate personnel before they are implemented.

This section will address contingency plans and operations for the inital observatory integration and buildup process, environmental testing, and the launch site activities. Also, this section will not only address contingency plans for flight hardware but will also address GSE and facility issues.

12.1 OBSERVATORY INTEGRATION AND BUILDUP CONTINGENCY PLANS

During the observatory integration and buildup process, all flight hardware for both the subsystems and instruments are expected to be delivered and ready for integration per the TRMM Project Schedule Baseline Document, document TRMM-490-165. This includes any and all GSE required to facilitate the process, e.g., the IGSEs for the instruments. The integration order depicted in this schedule is not only based upon deliverly and availablity of flight hardware but also on the dependency that one subsystem/instrument has on another (e.g., an instrument can't be integrated until the SDS is integrated since the SDS controls the instrument and provides telemetry and command interfaces for the instrument). However, for some subsystems/instruments there are no dependencies (e.g., one instrument is not dependent on another). In addition, at times there are planned work-arounds (e.g., the SDS requires a command interface from the transponder so a piece of GSE will be provided to simulate this interface until the transponders are integrated).

There are key subsystems must be in place as scheduled or there will be an impact since all other subsystems/instruments are dependent on these key subsystems. These subsystems are the structural subsystem, the power subsystem, the SDS, and the electrical subsystem (mainly the electrical and optical harnesses). Without these key subsystems there is little that can be accomplished and there are few contingencies planned. However, for the other subsystems/instruments there are many contingency plans that could be implemented which would allow progress to be made, thus not allowing the schedule to be grossly impacted due to the late deliverly and availablity of a subsystem, subsystem component, or instrument.

12.1.1 USE OF REDUNDANCY

The use of redundancy can be beneficial during the integration phase. These benefits are two fold: (1) allowing the system to operate, and (2) for interface verification. For example, if only SDS side-B is delivered and available for integration this will allow the system to operate thus allowing other subsystems/instruments to be integrated and tested, and by using BOBs or other means the subsystem/instrument operation can also be verified via the SDS side-A interface.

12.1.2 USE OF NON-FLIGHT UNITS AND SIMULATORS

The use of a non-flight unit or simulator could be used in place of a flight component to allow progress to be made. For example the Engineering Test Unit (ETU) of the SDS could be used until the flight unit becomes available, or until the SDS flight unit can be re-integrate after any needed repair work is performed.

12.1.3 GSE CONTINGENCY PLANS

The TRMM I&T effort is support by a large amount of GSE. This GSE includes BGSE, EGSE, SGSE, MGSE, and an IGSE for each instrument (see section 7.0 for a description for each of these types of GSE). During the TRMM Observatory integration and buildup process the use of this GSE is required to accomplish the task. For some of the key components of the EGSE and the SGSE spare parts or units will be available to replace failed parts or units. Also, during the observatory integration and buildup process the SGSE will be able (to a limited extent) to provide the functions of the IGSEs if one happens to fail. It is also important to noted that during the I&T effort at the GSFC, in general if GSE fails, its repair duration should be a few working days at the most.

12.2 OBSERVATORY ENVIRONMENTAL TESTING CONTINGENCY PLANS

In general, the plan is for the observatory integration and buildup process to be sucessfully completed before the environmental test program is to start. However, this may not be the case. Due to the continued unavailability of a flight hardware component, after a certain point, the environmental testing program must be started without that component in order to meet the overall schedule. Also, during the environmental test program, failure could occur with a flight component or an essential piece or GSE. In addition, during environmental testing, the available of a test facility or even a problem with a test facility may become a factor. The purpose of this section is to briefly address general contingency plans for these cases.

12.2.1 DELINQUENT OR MISSING FLIGHT HARDWARE

If the situation arises where a flight hardware component is delinquent for the start of environmental testing or fails just prior to the start of an environmental test, contingencies plans may have to be implemented to continue the I&T program in order to maintain schedule. These contingency plans would vary greatly depending on the test and on the hardware component that is delinquent or that has failed. However, these plans may include performing the test without that hardware item (a wavier would be required), once the delinquent of failed hardware item becomes available test it in a "standalone" mode, perform the test using an ETU or other flight like unit or spare unit, simulate the hardware component, rely on the test results for an identical unit, or a combination of any of these.

12.2.2 GSE CONTINGENCY PLANS

During environmental testing of the TRMM Observatory, in general the same GSE contingency plans apply as those during the observatory integration and buildup process (see paragraph 12.1.3).

12.2.3 ENVIRONMENTAL TESTING FACILITIES

f the situation arises where a environmental test facility is not available or is not functional when the TRMM Project requires it, contingencies plans may have to be implemented to continue the I&T program in order to maintain schedule. These contingency plans would vary greatly depending on the situation. However, these plans may include modifying the test flow, performing additional functional tests, perform troubleshooting (if any is required), or catching up on a number small pending miscellaneous I&T task. Environmental test facility usage will be closely scheduled with GSFC Code 750 to help ensure that no facility conflicts will occur.

12.3 LAUNCH SITE CONTINGENCY PLANS

Once environmental testing for the TRMM Observatory has been sucessfully completed at the GSFC, the observatory along with all required GSE will be shipped to the launch site in Japan (TnSC). Although the observatory has been completely tested and determined to be operating flawlessly before its shippment to the launch site, a complete set of functional tests will be performed at the launch site. In additional, the observatory must be readied for launch including fueling and pressurizing the RCS, integrating the flight batteries and solar array wings, installing pyrotechnics and arming plugs, closing out MLI, etc. During any of these operations if a problem with any of the flight hardware is discovered or if a critically essential piece if GSE brakes or malfunctions, established contingency plans will have to be implemented with the hope of not impacting the launch schedule. The purpose of this section is to briefly address general contingency plans for flight hardware or GSE failures at the launch site.

12.3.1 FLIGHT HARDWARE FAILURES

As soon as possible upon arrival at the TRMM launch site, the Observatory and required GSE will be configured in order to perform a full observatory level comprehensive performance test. The purpose of this test is to verify that the observatory is still operation flawlessly as designed and built. The reason that this test is performed as soon as possible upon arrival at the launch site is that, if there are any problems or failures with the flight hardware there will be as much time as possible to get them corrected before the scheduled launch date. There are few contingency plans for flight hardware failures at the launch site due to the fact that the launch site processing schedule is very sucess orientated.

12.3.2 GSE CONTINGENCY PLANS

The TRMM launch site I&T activities will required a large amount of GSE for handling, testing, and preparing the observatory for launch. Like at the GSFC, this GSE includes, BGSE, EGSE, SGSE, MGSE, and an IGSE for each instrument (see section 7.0 for a description for each of these types of GSE). Since GSE repare time at the launch site may be extensive, where possible for critically essential GSE, spare units or spare key components should be planned for and shipped to the launch site. Spares will be planned for critically essential EGSE and SGSE components. The SGSE can back up (to a limited extent) the IGSEs. In addition, GSE shipped to the launch site but not required initially shall be checkout in advance to verify its correct operation.

Description Of Appendices

The appendices listed in the table of contents (see page xxi) are not directly part of this document. However, the purpose of these appendices are sources of information directly pertaining to this document. They are not part of this document because the intent of this document is to give more of an overview of the I&T plans and process, test facilities, required GSE, test procedure requirements, and I&T responsibilities then the detailed I&T plans defined in these appendices. The intent is for this I&T plan to be agreed upon and signed off. The intent of the appendices is to contain various, detailed information pertaining to the TRMM I&T effort as it becomes available and is defined. These appendices are a "storehouse" of I&T information and are in a constant state of flux (i.e., they are the "living" part of this document). Unlike this document, they are not intended to be signed off. They are available upon request.